The Sources of Economic Growth in OECD Countries

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Foreword

In the last decade, per capita growth rates in OECD countries have ceased to converge. Productivity has accelerated in some of the most affluent economies, most notably the United States, and slowed down substantially in others, such as continental Europe and Japan, while signs of what has been named a "New Economy", driven by the upsurge of new technologies, have emerged. To understand some of the reasons behind these developments, and more generally to answer the request advanced in 1999 by OECD Ministers "to analyse the causes underlying differences in growth performance … and identify factors, institutions and policies that could enhance long-term growth prospects", the Organisation has produced a remarkable amount of comparative analysis and new research. While a short synthesis of the main findings and policy conclusions from this project has been published in a report to Ministers, The New Economy: Beyond the Hype, a single volume which pulls together the background research carried out by the Economics Department and other OECD Directorates has been lacking. This book aims to fill that gap.

What makes some countries seemingly able to thrive on new technological opportunities while others are held back? This book confronts this issue head on. It not only takes a long-term view on aggregate economic growth rates of OECD countries and examines their main influences and policy drivers, but also investigates how growth is determined at the industry and firm level. I think it can make the modest, but important, claim of moving us one step further towards a clearer image of what matters for growth and where policy should focus.

One of the most important lessons to emerge from this work is that policies that ensure stable macroeconomic conditions are important for growth, as high and variable inflation depresses investment and excessive tax burdens distort proper resource allocation. Also, the importance of capital – in the broadest sense – is reaffirmed; there are high returns not only to physical capital accumulation but also to investment in education and R&D. In addition, institutional structures and policy settings that favour competition and flexibility in capital and labour markets, the development of new technologies and the diffusion of innovations and technological change also make a key difference to growth prospects. In particular, many of our countries need more competitive product markets; labour markets that adjust better and more rapidly to shocks, both demographic and technological; and, financial systems that are able to direct capital flows, for given risks, towards projects with the highest returns.

This book also reminds us that the "new economy" is in part an old story. The upsurge in the use of information and communication technologies in the second half of the nineties has been spectacular in some countries through high levels of investment and utilisation. The evidence shows that this has clearly boosted efficiency and, when properly accounting for quality changes, has produced substantial capital deepening and higher growth rates, even if, so far, evidence of there being extra impacts from this wave of new capital due to network effects remains weak. The recent negative stock market and corporate developments are unlikely to change this assessment. But the new economy has also served to remind us how difficult it is to evaluate growth when new technologies are being rapidly developed and implemented, accompanied by swings of optimism and pessimism about the economic value of these advances.

To be sure, economic growth is neither a mechanical nor a smooth process. Institutions and regulations play a crucial role in determining the path of growth. But if the "rules of the game" start being perceived as blurred and non-transparent, capital deepening and productivity enhancements may suffer. More generally, macroeconomic stability and well-functioning markets cannot be taken for granted even where they have best served the cause of economic growth in the last decades. Furthermore, contrary to simplistic beliefs, regulatory reforms are not the same as unconstrained deregulation; enhanced competition does not mean uncontrolled laisser-faire; and the reduction of excessive employment protection does not inevitably imply widespread job-insecurity. The quest for the most appropriate conditions to foster investment opportunities and economic growth needs to focus on enhancing market efficiency and innovation, promoting the accumulation of knowledge and increasing the diffusion of new technologies. The OECD's on-going monitoring of the developments and impacts of these new technologies will, I hope, help bring us closer to an understanding of the real nature of the "new economy" and where it is heading.

These messages on how policymakers can help growth are perhaps not completely new but the evidence in this volume gives us reason to believe they should be made more forcefully so as to encourage a thorough assessment of institutions and structural policies in the OECD countries.

Ignazio Visco
OECD Chief Economist, 1997-2002

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The Sources of Economic Growth in the OECD Countries

Summary and Policy Conclusions

Strong economic growth in some OECD countries over the 1990s, most notably in the United States, led many commentators to speculate that a "new economy" had emerged, largely driven by the spread of information and communication technology (ICT). In particular, economic performance in the United States included a combination of strong output and productivity growth, together with falling unemployment and low inflation. These patterns were all the more surprising for a country already at the technology frontier in many industries, and had no similar counterpart in other affluent OECD economies. Indeed, over the 1990s, large continental European countries, and Japan, experienced slow economic growth and rising, or persistently high unemployment.

Two main features were put forward as characterising this new economy phase. First, ICT may have led to an upward shift in the growth path in those economies where it was most widespread. Indeed, some of the fast-growing countries of the 1990s (such as the United States and, more recently, Finland) developed a sizeable ICT-production industry, whose output and productivity soared, increasingly contributing to aggregate growth. Yet, growth also accelerated in some countries without an ICT-production industry (*e.g.* Australia and the Netherlands) and the sizeable ICT sector in Japan did not prevent it from experiencing a significant deceleration. But ICT may also have influenced growth *via* other channels. In particular, greater use of ICT equipment in the production process of other industries enhanced aggregate growth in some of the countries lacking an ICT-production industry (*e.g.* Australia).

It could be argued that the interest of policymakers and analysts in the impact of ICT on economic growth should have evaporated along with the new-economy hype and the over-valuation of ICT-related stocks. Yet, behind the falling stock prices, IC-related technologies continue to have the potential to affect the quality and variety of goods and services, as well as the costs of transaction between many economic agents. In addition, the use of ICT may be increasing the efficiency of innovation, further contributing to long-term growth potential.

Of course, the spread of ICT was not the only factor shaping the economic landscape of the OECD economies in the 1990s. It was a period characterised by sound macroeconomic policy settings, as well as structural reforms in product, labour and financial markets in several countries. The pace and

depth of structural reforms differed significantly across countries, with some (generally small) countries (*e.g.*, Australia, Ireland, Netherlands, New Zealand) pursuing major changes, while others (including several large economies) were being somewhat more hesitant, particularly with reforms in product and especially the labour markets.

The book presents an in-depth reflection on what has been driving economic growth in OECD countries over the most recent decades. What do recent estimates say about the impact of the spread of ICT on growth? Why have some economies been able to harness the potential of this technology better than others? How and how much, does government activity contribute to long-term growth, not least by creating suitable framework conditions for innovation and the adoption of new technologies? What policies (macro as well as structural) should be advocated for sustainable long-term growth? What lessons do policy practices in individual countries have for others?

The analysis is based on a newly developed set of indicators of policy and regulations in different markets to disentangle the effect of the various factors at work, and to examine how they affect specific sectors of the economy. Different tools are used to exploit this information and assess the sources of economic growth. They range from growth-accounting methods, offering a decomposition of growth into contributions from various factors of production at the aggregate and sectoral levels, to regression analyses at the macro, industry and micro levels, aiming at identifying causal links between growth and policy-relevant factors. Drawing from these complementary analyses, a major challenge of the book is to offer a consistent view of the growth process.

Main findings

Growth disparities across the OECD countries have indeed widened...

The review of aggregate growth trends (Chapter 1) suggests that across the OECD area as a whole, GDP growth was lower in the 1990s compared with the previous decade, continuing the well-documented slowdown in growth rates. However, the perceived view of growing disparities across the OECD economies is confirmed by the review of individual countries' performance. While some countries saw an acceleration in growth, most notably in the United States and some smaller economies (Australia, Ireland and the Netherlands) in others, mainly large continental European countries and Japan the pace of growth continued to slow down.

... largely because of differences in employment patterns

Decomposition of GDP per capita growth shows that both labour productivity and employment rates are key in explaining these divergent growth patterns. In particular, countries with low or falling labour utilisation (*i.e.* the fraction of employed persons in total working age population) have generally experienced a slowdown in GDP per capita, as labour productivity growth did not fully offset the reduced productive capacity. Growth in labour productivity can partially be explained by the enhancement of "human capital" amongst those in employment. Yet, in some (mainly European) countries, it also reflects the exclusion of the low-skilled from work.

ICT has also contributed to boost growth in some countries, mainly by offering new investment opportunities

The decomposition of aggregate growth also suggests that, albeit still relatively small in most countries, the ICT-producing industry has contributed to growth, albeit by a relatively small amount in most countries, but more so, notably in the United States and Finland. More interestingly, perhaps, ICT has also shown its potential as a driver of growth by influencing the traditional process of "capital deepening" (*i.e.* the increased intensity of physical capital per unit of labour). Indeed, rapidly falling ICT prices have stimulated ICT investment, whose share in total investment has risen sharply in several economies (*e.g.* United States, Finland, Australia and Canada).

The book also looks for evidence of additional gains from the spread of ICT through more efficient work organisation, and broader communication between producers as well as between producers and consumers (so-called spillover and network effects). In addition, this new technology has allowed new businesses and markets to flourish rapidly in new areas of the economy. Using a standard proxy for technological progress, multi-factor productivity (MFP) growth, there is evidence that these processes have been particularly important in Australia, Canada and the United States in the second half of the 1990s. However it should be stressed that the more straightforward sources of productivity gain have typically dominated the statistics to-date. Pick-ups in productivity growth have been mainly driven by greater use of highly productive ICT equipment in many industries (*i.e.* technological change "embodied" in productive capital) and faster technological progress in the ICT industry itself in those countries where this industry has a relevant size. This being said, innovative ICT-based businesses and markets are still at an early stage of development and further changes may be expected in the future. In this context, the resilience of MFP growth in the face of the economic slowdown experienced over the past two years, notably in the United States

seems to confirm that the pick-up observed in the second part of the 1990s had a strong permanent component.

Looking at the drivers of growth, investment in human, physical and knowledge capital is key…

The book then takes a long-term view on economic growth (Chapter 2) by examining the links between general framework conditions, policy settings and aggregate growth in the OECD countries over the past three decades. The chapter first examines the direct influence of human capital, research and development activity, macroeconomic and structural policy settings, trade policy and financial market conditions and growth. It then looks at the effect many of these factors have on the accumulation of physical capital–and therefore indirectly on growth.

Not surprisingly, it is found that the pace of accumulation of physical and human capital plays a major role in the growth process. Most notably, the estimated impact of increases in human capital (as measured by average years in education) on output suggests high returns to investment in education. The results also point to a marked positive effect of business-sector R&D, while the analysis could find no clear-cut relationship between public R&D activities and growth, at least in the short term. The significance of this latter result should not however be overplayed as there are important interactions between public and private R&D activities as well as difficult-to-measure benefits from public R&D (*e.g.* defence, energy, health and university research) from the generation of basic knowledge that provides technology spillovers in the long run.

… and can be encouraged by appropriate macroeconomic policies

Policy and institutions are also found to play an important role in shaping long-term economic growth. In particular, high inflation tends to dampen incentives to invest in the private sector and, through this channel, has a negative bearing on output. Moreover, the uncertainty generated by highly volatile prices seems to curb economic growth by shifting the composition of investment towards less risky, but also lower-return projects. In addition, there is some support to the notion that the overall size of government in the economy may reach levels that impair growth. Although expenditure on health, education and research clearly sustains living standards in the long term, and transfers help to meet social goals; all have to be financed and high levels of taxation, as well as high government deficits, crowd out resources that could be used to raise growth potential. For a given level of taxation moreover, higher direct as opposed to indirect taxes further weaken growth

potential. On the expenditure side, transfers, as opposed to government consumption and – even more so – investment, could lead to lower output per capita. Finally, well-developed financial markets, both by helping to channel resources towards the most rewarding activities and by encouraging investment, contribute to long-term growth.

Pro-competitive regulations improve productivity performance…

Examination of what drives productivity growth in individual industries (Chapter 3) generally suggests that pro-competitive regulations improve industry-level productivity performance by enabling a faster catch-up to best practice in countries that are far from the technological frontier. This is because in weakly competitive markets there are relatively few opportunities for comparing firm performance, and firm survival is not immediately threatened by inefficient practices. Under competitive pressure, performance comparisons are easier and the risk of losing market share encourages the elimination of slack. In parallel, the need to be cost efficient provides a powerful motivation for adjusting technology to best practice.

One reason why pro-competitive regulations help growth is because they promote innovation. Product market regulation is good for innovation if it provides intellectual property rights that induce innovation, and while also restricting the scope for potentially anti-competitive strategic use of innovation spending or patenting. Labour market regulations are also found to influence innovation but the impact appears to be conditional on other institutional aspects of the labour market. For example, innovation-driven changes in the job skill mix often imply hiring and of firing workers, which is easier with less statutory job protection. However, in countries where industrial relations lead to wage compression across skills and inter-firm practices imply a close co-operation amongst employers, changes in the skill mix are often implemented by in-house training of the existing workforce. In these circumstances, restrictions on workers' turnover may not be a major impediment to adoption of new technologies and innovation. The impact of employment protection legislation on innovation also varies across industries, reflecting the degree to which innovation-driven labour adjustments have to be accommodated through worker turnover. In particular, strict employment protection legislation (EPL) seems to deter R&D activity especially in industries where the innovation process is driven by strong product differentiation, with technologies being often renewed through entry and exit of firms and extensive worker turnover. Conversely, strict employment protection does not appear to be a constraint on R&D in high-technology industries characterised by cumulative innovation processes. In these industries, the best worker competencies to complement innovation are often found within the firm and

upgrading skills of existing employees may be less costly than training new workers.

… and encourage productivity by facilitating the entry of innovative firms

The final part of the book (Chapter 4) examines firm dynamics (the entry, expansion and exit of firms in each market) and their contribution to productivity growth for a sample of OECD countries, including the United States and most of the large European economies. It uses a novel firm-level database which contains detailed information for manufacturing and service sector industries. Within each industry, the bulk of productivity growth comes from existing firms' performance. However, the contribution of the entry and exit of firms in each market varies significantly across countries. In Europe, new firms generally provide a positive contribution to industry productivity growth. In the United States they tend to be, on average, less productive than incumbents, while a stronger contribution to productivity growth arises from the exit of obsolete firms.

Looking more closely into firm dynamics suggests a similar degree of "firm churning" in the countries analysed, *i.e.* a large number of firms enter and exit most markets every year. The early years are the most difficult for entrants: about a third of entering firms do not survive the first two years. Moreover, entry and exit rates are highly correlated across industries, pointing to a process of "creative destruction" in which a large number of new firms displace a large number of inefficient ones. This does not prevent the likelihood of failure of entrants from being high, especially for small firms, suggesting that creative destruction also involves a great deal of market experimentation. Both European and US firms share these general features, although there are interesting differences: US entrant firms appear to be relatively smaller and less productive than their EU counterparts, but they grow faster when successful.

The book offers some rationale for these differences. It indicates that strict regulations on entrepreneurial activity and high costs of adjusting the workforce do not necessarily affect overall entry conditions but rather contribute to shape the characteristics of entrants, most notably their relative size. Thus, in the United States, low administrative costs of start-ups and not unduly strict regulations on labour adjustments are likely to stimulate potential entrepreneurs to start on a small scale, test the market and, if successful with their business plan, expand rapidly to reach the minimum efficient scale. In contrast, higher entry and adjustment costs in Europe may stimulate a pre-market selection of business plans with less market experimentation. In addition, the more market-based financial system

existing in the United States may lead to a lower risk aversion to project financing, with greater fund-raising opportunities for entrepreneurs with small or innovative projects, often characterised by limited cash flows and lack of collateral.

Policy considerations

Evidence provided in this book clearly indicates an articulated agenda for policy makers interested in setting a sustainable growth-oriented strategy. Some traditional factors affecting incentives to invest in physical, human and knowledge capital, as well the functioning of product, labour and financial markets have been crucial for steering some countries on a higher growth path, while keeping others on a lower one. The OECD, as well as other national and international institutions, has proposed comprehensive policy prescriptions on how to foster growth-oriented investment and improve the functioning of different markets.

There have also been significant changes in the OECD economies, brought about by the rapid spread of a general-purpose technology (ICT) that is changing work organisation practices, production processes and the relationships between consumers and producers. While it is probably too early to say how important these changes will be for the future of OECD economies, governments are currently asked to take them into account and ensure that their economies can benefit from such changes, while keeping social costs low. The analysis in the book suggests that differences in policy and institutional settings across countries – and the different pace of reforms therein – have already contributed to shape the ability of OECD economies to reap the full benefits of the new IC technology. In particular, providing more scope for risk-takers to explore new business opportunities, as well as improving the ability of firms and workers to quickly adapt to changing demands and workplace organisation, are likely to assume an even greater role for steering growth potentials.

These issues are further discussed in the remainder of this section, while more in-depth policy recommendations are available in other OECD publications, including the OECD Ministerial report on growth "*The New Economy: Beyond the Hype*" published in 2001.

Getting the fundamentals right

There is clear evidence that a sound macroeconomic policy setting is a key ingredient for sustainable, long-term growth. This may lead to some optimism for future growth developments. Indeed, most OECD countries have made significant progress towards price stability and avoiding excessive

macroeconomic fluctuations. Nevertheless, while there have been successful efforts to reduce public sector deficits, the overall tax pressure is still high in a number of OECD economies and has risen in the past decade. This is all the more problematic given the ageing of the populations in most OECD countries and the need to finance greater expenses for pensions and health care systems.[1] The structure of the tax system is also important. In particular, countries that rely more heavily on direct taxes to finance government activities may suffer from relatively lower output growth, given the more direct negative effects of such taxes on investment and labour. Likewise, certain features of tax regimes can encourage or discourage entrepreneurship and the growth of small businesses, compelling elements for harnessing the potential of innovation and diffusion of new technologies. For example, high personal income tax rates can discourage entrepreneurship since entrepreneurs are self-employed and/or managing unincorporated businesses, whose profits are taxed through the application of a progressive rate schedule to personal income. The choice for small firms to expand or not may also depend on the relative tax treatments between corporate and non-corporate firms; only some OECD countries have a (relatively) neutral system in this respect, although some have recently made reforms in this direction.

With respect to human capital, most OECD countries have recorded significant improvements in the level of skills and education of the workforce in past decades, not least because of government intervention. Even if there may be diminishing social returns to any given increase in education levels, these developments have had (and will continue to have) a positive impact on long-term growth. However, there remain significant cross-country differences in the average skill level – as well as the distribution across the population– which requires further efforts in a number of countries. Moreover, as discussed in other OECD studies,[2] the effectiveness of further increases in human capital greatly depends upon the type and quality of education. The spread of ICT also poses new challenges to government intervention in education. In particular, unequal access to this technology and learning how to use it effectively may lead to a knowledge divide. This may apply across youths still enrolled in the education system, and probably calls for further efforts to better integrate ICT into teaching and learning. But the ICT knowledge divide also applies across cohorts of workers who have had different exposure to this technology at school or during their work experience. This second dimension of the divide calls for greater effort on adult learning and, in particular, a better distribution of vocational training across different categories of workers.[3]

Over past decades, there has also been a generalised tendency in OECD countries towards increasing the amount of resources devoted to R&D – although there has been some reduction in recent years, largely due to falls in

defence-related government outlays. Another positive move has been the greater amount of R&D resources directly channelled to the business sector, with a greater role played by firms themselves. This shift may have positive implications for the effectiveness of innovation activity given that, as stressed above, there are significant differences in the returns of R&D expenditure across sectors, and the private sector may be better able to channel resources towards high return R&D activities. Creating adequate conditions for proper intellectual property rights is particularly important. Many OECD governments also encourage R&D and innovation in the private sector by using grants, subsidies, loans and tax credits. Evidence of large differences in the scope and expected returns of R&D activity across sectors seems to speak in favour of a more market-based (*e.g.* tax credits) strategy, instead of resorting to direct forms of support to specific industries, unless the latter are motivated at directing industrial R&D towards areas with potentially large social benefits.[4]

As well as improving the functioning of product, labour and financial markets

Against a backdrop of general framework conditions for sustainable growth, there is a need to pay special attention to specific areas of policy that may be of particular relevance for the spread of new technologies, including ICT. This requires policy attention in various areas. The evidence presented here suggests that entrepreneurial activity contributes extensively to innovation and adoption of new technologies and, ultimately, to productivity growth. New technologies are often more efficiently harnessed through the creation of new enterprises and the redesign of existing ones, both factors depending on the entrepreneurial environment. The latter, in turn, is influenced by product market regulation affecting start-up costs as well as competitive pressures in the market, alongside other influences, such as access to finance, taxation, education and employment regulations.

Administrative regulations concerning start-ups (*e.g.* licences and permits, communication rules, administrative burdens, legal barriers to entry) are key to explaining start-up activities. In a number of OECD countries, including many in continental European, regulations in the registration of new businesses are either excessive or unduly complicated and drawn out. This adds to the fixed costs of setting up a firm and particularly discourages small start-ups, especially in markets characterised by high uncertainty such as those where new technologies are important. Would-be innovative entrepreneurs can be put off not just by high entry costs, but also by difficulties to exiting business. In particular, the very stringent bankruptcy policies observed in some countries, while perhaps conducive to prudent

decision-making amongst managers, are likely to limit incentives to undertake risky projects, leading to less innovation.

Pro-competitive product market regulations are also important for promoting managerial efficiency and ultimately innovation, the adoption of new technologies and growth. Indeed, the evidence of a particularly strong negative effect on productivity of stringent regulations affecting industries where countries have accumulated significant technological gaps may explain why many European countries are lagging behind in the development of the ICT industry. In turn, the effects of strict product market regulations on the process of innovation itself also explain these technological gaps. Broad policy initiatives have generally contributed to spur competition in the product market, but administrative regulations and state controls (over prices and market entry) still interfere with competition and productivity growth in a number of OECD countries.

By fostering employment opportunities, well-functioning labour markets are also essential for achieving high economic growth and for insuring that subsequent benefits are shared amongst the entire population. In a period of rapid technological change, labour market institutions are faced with the dual challenge of minimising the potential hardship that these changes can create, while ensuring an efficient reallocation of labour resources across sectors and firms. These issues have been emphasised in the OECD *Jobs Strategy* and specific policy and regulations that fail to support workers in finding new jobs, and hinder effective reallocation of labour, have been reviewed in many countries.[5] The evidence in the book underscores the interdependence of employment protection legislation and industrial relations.

In particular, the evidence presented here suggests that labour market policies influence the way in which innovative activity is carried out because the combined effects of hiring and firing costs and the type of industrial relations regime affect firms' incentives to conduct in-house training. A combination of strict employment protection legislation, wage compression across skills and lack of co-ordination amongst employers, as seen in several continental European countries, lowers incentives for innovation and the adoption of leading technologies. The way in which technology changes also plays a role. In countries with co-ordinated industrial relations regimes (*e.g.* Austria and Germany), strict employment protection legislation is less likely to affect innovation in industries where technology evolves in a cumulative fashion (with a parallel evolution of the workforce skills), compared with industries where technologies, and techniques (and skill requirements) change dramatically. In house training is more easily used (and thus the costs of EPL avoided) in the former case compared with the latter.

To enhance the benefits for new technologies and to realise the potential of human capital, firms are often required to change work organisation. New work practices associated with new technologies include teamwork, flatter management structures, employee involvement and suggestion schemes. These changes generally involve greater responsibility of individual workers regarding the content of their work and closer relationships with management which, in turn, call for more flexible working conditions and wages. Thus, reaping the most from new technologies may require changes in wage-setting schemes, with greater emphasis on performance-related pay.

There is also evidence that a well-developed financial system is an important aspect of a favourable environment for growth, especially in a period of the rapid spread of a new technology when they can promote new, innovative enterprises. In this regard, "venture capital", has attracted particular attention. Venture capital typically consists of equity, or equity-linked investments in young, privately held companies, and has often served as seed money in high-tech businesses. The fact that high-risk capital appears to have developed more rapidly in some countries compared with others suggests that differences in financial framework conditions may be influential in determining incentives to invest in innovative projects and, ultimately, the rate of innovation itself. In particular, the United States and Canada have the most developed venture capital markets in the OECD area, both in terms of its absolute size and, more importantly, in terms of the share of venture capital investment going to the early stages of enterprise formation and to the higher technology sectors. In other words, in North America, venture capital is being directed to where it is most needed, namely to riskier high-technology start-ups. In contrast, in Europe and Japan, venture capital seems to be directed more towards traditional sectors at later stages of enterprise development. These differences are likely to contribute to the observed different nature of start-ups in the United States, compared with Europe and Japan, and may require policy action.

The increased role of ICT in OECD economies raises a number of additional policy issues that are not discussed in the book.[6] Reaping the full benefits of ICT requires, for example, the removal of barriers to network access. Moreover, regulatory reforms are still needed to foster competition in some ICT-related activities, such as mobile telephony. At the same time, there are also features of the IC technology that pose new challenges to competition: certain products become more useful as more people use them (*e.g.* networks or software) and economies of scale in their production can be large, both factors making it more difficult for other enterprises to enter a market where an incumbent is already established. The spread of e-commerce has implications for tax revenues, privacy and consumer protection that are

difficult to tackle given the borderless nature of the net and the many jurisdictions involved.

Overall the book suggests that long-term sustainable economic growth has many sources and cannot be fully steered by policy-makers. Nevertheless, growing disparities in growth patterns over the past decade can, at least partially, be attributed to differences in policy settings and reforms therein. While there have been significant improvements toward sound macroeconomic policy in most OECD countries, structural differences remain significant in a number of areas, and reforms have been diverse. In this context, the spread of a new technology (ICT) over past decades has not fundamentally changed the policy prescriptions for sustainable long-term growth. It has rather offered a "natural experiment" to test existing policies and draw important policy lessons for future reforms.

Notes

1. See OECD (1998), *Maintaining Prosperity in an Ageing Society*, Paris.
2. See OECD (2002), *Education at a Glance*, Paris.
3. See OECD (2001), *Understanding the Digital Divide*, Paris.
4. See OECD (2001), *Science, Technology and Industry Outlook – Drivers of Growth*, Paris; and Guellec and Van Pottelsberghe (2001).
5. See OECD (1994), *The OECD Jobs Study*, Paris; and OECD (1999), *Implementing the OECD Jobs Strategy: Assessing Performance and Policy*, Paris.

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Chapter 1

Economic Growth: the Aggregate Evidence

Abstract. *This chapter[1] presents an overview of growth performance in OECD countries over the past two decades. Special attention is given to developments in labour productivity, allowing for human capital accumulation and multi-factor productivity (MFP), allowing for changes in the composition and quality of physical capital. The chapter suggests wide (and growing) disparities in GDP per capita growth, while differences in labour productivity have remained broadly stable. Countries that have managed to improve their growth performance share some common elements: improvements in labour utilisation; a generalised enhancement of human capital; and a rapid adoption of the new information and communication technology by many industries.*

Introduction

The aim of this chapter is to ascertain how OECD countries' growth performance has evolved over the past decade, whether growth disparities are indeed widening, and which factors are immediately responsible. The chapter describes which countries have done particularly well, or badly, in terms of output and productivity growth over recent years and which factors support growth from an accounting perspective. Particular attention is given to labour productivity growth, allowing for human capital accumulation, and multi-factor productivity (MFP), allowing for changes in the composition and "quality" of physical capital.

The structure of the chapter is as follows. Section 1.1 examines cross-country patterns of GDP and GDP per capita growth and their main determinants across the OECD area over the past decade. Since labour productivity has played a major role in shaping aggregate growth, Section 1.2 looks more closely into it and, in particular assesses how enhancements in human capital have contributed to foster productivity growth. Section 1.3 then takes a preliminary look at the role played by information and communication technology (ICT) as a driver of growth in OECD countries over the past decade. This is done by focusing on both the direct effects on productivity, reflecting growth in the ICT-producing industry, and the indirect effects, *via* the use of ICT as an input to production in other sectors. An interesting finding is that the sharp decline in ICT relative prices has led to a major shift in the composition of investment towards ICT equipment. Thus, Section 1.4 examines how this shift in the composition of capital has affected multi-factor productivity (MFP) growth, a proxy for technological progress. Interestingly, countries that experienced some improvements in MFP growth in the 1990s include those with a sizeable ICT-production industry, where productivity growth accelerated dramatically over the past decade, but also those which invested heavily on highly productive ICT equipment.

1.1. Recent cross-country growth patterns

Trend growth rates in GDP and GDP per capita

It should be stressed at the outset that international comparisons of growth patterns are constrained by a number of measurement issues. Comparability problems have always affected international analyses of

growth performances but are particularly relevant at present because of the different pace and comprehensiveness with which different countries have adopted new measurement techniques in their national accounts (mainly related to the shift to the new System of National Accounts, 1993 SNA).[2] Moreover, the method to construct price indices of ICT equipment (*e.g.* computers and peripheral equipment) varies between OECD countries. This affects estimates of output growth in both ICT-production industries as well as in industries that use extensively ICT equipment. Some countries try to account for the rapid quality changes in ICT by applying so-called "hedonic" methods in the construction of price indices.[3] Hence, *ceteris paribus,* the growth rate of production price deflators of ICT-producing industries will be lower, and the growth rate of output volumes consequently higher, in those countries using hedonic methods than in those that do not. At the same time, in countries using hedonic methods in the construction of price indexes for ICT equipment, the estimated productivity of ICT-using industries may be underestimated, unless hedonic methods are also used to account for possible quality changes in their output. Measurement problems are compounded by the notorious difficulty of measuring output in some service sectors, including those where quality aspects of output are important (*e.g.* financial intermediation).

Another complication inherent in international comparisons of growth performance in the short- to medium-term is that cross-country differences in output growth rates and levels may reflect differences in cyclical positions, as well as underlying differences in performance. Despite some evidence of reduced cyclical divergence in most recent years (Dalsgaard *et al.*, 2002), the experience of the 1990s is one of large differences in business cycles across OECD countries. To control for these problems, frequent use is made in this chapter of trend series (see Box 1.1).

For the OECD area as a whole, cyclically adjusted GDP growth was, on average, lower in the 1990s compared with previous decades, continuing the well-documented long-run slowdown in growth rates (Table 1.1). However, the trend was reversed in the United States and Canada, as well as in several smaller OECD countries (most notably Australia, Ireland, the Netherlands, Norway and Spain). Cyclically adjusted growth rates in GDP per capita – which are more relevant from a national living standard perspective – presented broadly the same picture (Table 1.1).[4] These different growth patterns were associated with a widening of GDP growth disparities in the 1990s when compared with the 1980s, as shown by the increase in the cross-country standard deviation of growth rates.

Box 1.1. **Trend series: the extended Hodrick-Prescott filter**

In this chapter, an attempt is made to identify underlying trends in aggregate variables from observed series. Trend series for output, employment and productivity have been estimated using an extended version of the Hodrick-Prescott filter, Hodrick and Prescott, 1997 (see Annex 1 for more details). The cyclical component in actual data is separated from the trend component under the assumption that the former has only a temporary effect, while the latter persists. The usual problem of distinguishing between cyclical and trend components towards the end of the sample period is tackled in the extended version of the H-P filter by extending actual data out of the sample using the observed average growth rate over the 1990-2000 period. However, if past growth rates are not reasonable proxies for future growth patterns, this extension may lead to a bias at the end of the filtered series. For the majority of countries, the bias does not appear to be serious: an alternative method of extending the data so as to better anchor the smoothed series – using the projections in the OECD Medium Term Reference Scenario,[1] (MTRS) – provided broadly similar results. There are, however, a few exceptions. Amongst the G-7 countries (see Table below), only in Japan does the use of OECD MTRS projections lead to a somewhat lower cyclically adjusted growth rate over the 1990s. The same effect is also present in Ireland, Korea, Mexico and Turkey. By contrast, the use of MTRS leads to a higher cyclically adjusted GDP growth rate in Greece.

1. In the context of its bi-annual projection exercise, the Economics Department of the OECD produces a set of medium-term projections, looking out five years. These projections assume that at the end of the projection period output will be at its potential and unemployment will reach its structural level. Further details and data can be found at *www.oecd.org/pdf/M00026000/M00026369.pdf*. The data used in the table in Box 1.1 are from *Economic Outlook 70*.

Living standards in 2000: a widening gap across OECD countries

These divergent growth trends over the past decade have also resulted in widening living-standard conditions in the OECD area. The process of convergence that characterised the post-war period and that, albeit at a lower pace, continued through the 1980s, came to a halt in recent years. In the 1990s, there were only a few high-growth countries (*e.g.* Ireland, Korea) that were still engaged in a process of catch-up, while strong US growth meant that the gap between its per capita income levels and those of most other OECD countries started to widen again. Not surprisingly, data for 2000 show the United States well at the top of the OECD income distribution, followed by

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Box 1.1. **Trend series: the extended Hodrick-Prescott filter** *(cont.)*

Estimates of cyclically-adjusted GDP growth

Total economy, percentage changes at annual rates

		1980-1990	1990-2000[1]	1996-2000
United States	Actual	3.2	3.2	4.2
	EHP filter (trend)[2]	3.1	3.3	3.7
	EHP filter (project.)[3]	3.1	3.2	3.7
Japan	Actual	4.1	1.3	0.7
	EHP filter (trend)[2]	3.9	1.7	1.1
	EHP filter (project.)[3]	3.9	1.5	0.7
Germany[4]	Actual	2.2	1.6	2.0
	EHP filter (trend)[2]	2.2	1.5	1.7
	EHP filter (project.)[3]	2.2	1.5	1.7
France	Actual	2.4	1.8	2.9
	EHP filter (trend)[2]	2.2	1.9	2.3
	EHP filter (project.)[3]	2.2	1.9	2.3
Italy	Actual	2.2	1.6	2.1
	EHP filter (trend)[2]	2.3	1.7	1.8
	EHP filter (project.)[3]	2.3	1.7	1.9
United Kingdom	Actual	2.7	2.3	2.9
	EHP filter (trend)[2]	2.5	2.4	2.7
	EHP filter (project.)[3]	2.5	2.4	2.7
Canada	Actual	2.8	2.8	4.4
	EHP filter (trend)[2]	2.6	2.8	3.6
	EHP filter (project.)[3]	2.6	2.7	3.4

1. 1991-2000 for Germany.
2. Extended H-P filter based on trend growth (1990-2000) to extend time-series out of sample.
3. Extended H-P filter based on OECD MTRS projections to extend time-series out of sample.
4. Western Germany before 1991.

Source: OECD.

Norway, Canada and Switzerland with GDP per capita about 15-20 percentage points below the US level (Figure 1.1). The bulk of the OECD, including all other major economies, lagged behind per capita GDP in the United States by 25-35 percentage points.

Figure 1.1 suggests that labour utilisation (employment rates combined with hours worked) is an important factor in accounting for differences in the GDP per capita levels across countries, whereas the age composition of the population plays a very minor role. A number of countries (*e.g.* the United States, Japan) have high employment rates and higher than average hours worked, while most of the Nordic countries have even higher employment

Table 1.1. **Uneven growth of GDP across the OECD countries**

Average annual rates of change, 1970-2000

	Actual growth of GDP				Actual growth of GDP per capita				Trend growth of GDP per capita		
	1970-1980	1980-1990	1990[1]-2000	1996-2000	1970-1980	1980-1990	1990[2]-2000	1996-2000	1980-1990	1990[2]-2000	1996-2000
United States	3.2	3.2	3.2	4.2	2.1	2.2	2.2	3.3	2.1	2.3	2.8
Japan	4.4	4.1	1.3	0.7	3.3	3.5	1.1	0.5	3.3	1.4	0.9
Germany[3]	2.7	2.2	1.6	2.0	2.6	2.0	1.3	2.0	1.9	1.2	1.7
France	3.3	2.4	1.8	2.9	2.7	1.8	1.4	2.6	1.6	1.5	1.9
Italy	3.6	2.2	1.6	2.1	3.1	2.2	1.4	1.9	2.3	1.5	1.7
United Kingdom	1.9	2.7	2.3	2.9	1.8	2.5	1.9	2.4	2.2	2.1	2.3
Canada	4.3	2.8	2.8	4.4	2.8	1.5	1.7	3.5	1.4	1.7	2.6
Austria	3.6	2.3	2.3	2.7	3.5	2.1	1.8	2.6	2.1	1.9	2.3
Belgium	3.4	2.1	2.1	3.2	3.2	2.0	1.8	3.0	2.0	1.9	2.3
Denmark	2.2	1.9	2.3	2.8	1.8	1.9	2.0	2.4	1.9	1.9	2.3
Finland	3.5	3.1	2.2	5.3	3.1	2.7	1.8	5.0	2.2	2.1	3.9
Greece	4.6	0.7	2.3	3.7	3.6	0.2	1.9	3.5	0.5	1.8	2.7
Iceland	6.3	2.7	2.6	4.6	5.2	1.6	1.6	3.4	1.7	1.5	2.6
Ireland	4.7	3.6	7.3	10.4	3.3	3.3	6.4	9.2	3.0	6.4	7.9
Luxembourg	2.6	4.5	5.9	7.1	1.9	3.9	4.5	5.7	4.0	4.5	4.6
Netherlands	2.9	2.2	2.9	3.8	2.1	1.6	2.2	3.2	1.6	2.4	2.7
Norway[4]	4.4	1.5	2.8	2.6	3.8	1.1	2.2	2.0	1.4	2.0	2.2
Portugal	4.7	3.2	2.7	3.6	3.4	3.1	2.5	3.2	3.1	2.8	2.7
Spain	3.5	2.9	2.6	4.1	2.5	2.6	2.5	4.0	2.3	2.7	3.2
Sweden	1.9	2.2	1.7	3.3	1.6	1.9	1.4	3.2	1.7	1.5	2.6
Switzerland	1.4	2.1	0.9	2.2	1.2	1.5	0.2	1.8	1.4	0.4	1.1
Turkey	4.1	5.2	3.6	3.1	1.8	2.8	1.8	1.5	2.1	2.1	1.9

Table 1.1. **Uneven growth of GDP across the OECD countries** *(cont.)*

Average annual rates of change, 1970-2000

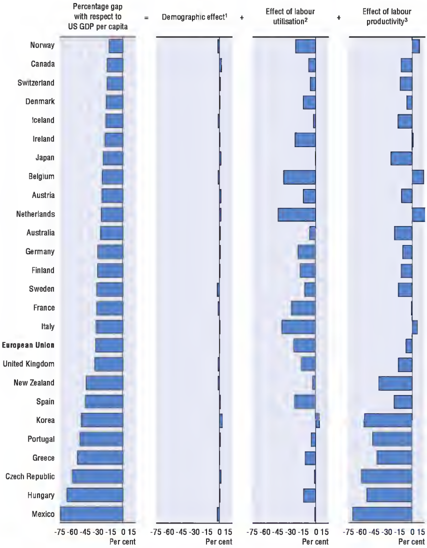
	Actual growth of GDP				Actual growth of GDP per capita				Trend growth of GDP per capita		
	1970-1980	1980-1990	1990[1]-2000	1996-2000	1970-1980	1980-1990	1990[2]-2000	1996-2000	1980-1990	1990[2]-2000	1996-2000
Australia	3.2	3.2	3.5	4.2	1.5	1.7	2.3	3.0	1.6	2.4	2.8
New Zealand	1.6	2.5	2.6	2.2	0.5	1.9	1.2	1.4	1.4	1.2	1.8
Mexico	6.6	1.8	3.5	5.6	3.3	–0.3	1.7	4.2	0.0	1.6	2.7
Korea	7.6	8.9	6.1	4.3	5.8	7.6	5.1	3.3	7.2	5.1	4.2
Hungary	..	..	2.3	4.7	..	..	3.4	5.1	..	2.3	3.5
Poland	..	..	3.6	4.9	..	..	3.5	4.9	..	4.2	4.8
Czech Republic	..	..	1.5	0.1	..	..	1.6	0.2	..	1.7	1.4
Slovak Republic	..	..	4.6	3.6	..	..	4.4	3.5	..	..	..
Weighted averages											
EU15	3.0	2.4	2.0	2.9	2.6	2.1	1.7	2.6	2.0	1.8	2.2
OECD24[5]	3.4	3.0	2.5	3.2	2.5	2.3	1.8	2.6	2.2	1.9	2.2
Standard deviation:											
EU15	0.92	0.86	1.62	2.19	0.70	0.85	1.39	1.88	0.79	1.35	1.56
OECD24[5]	1.17	0.96	1.38	1.92	1.02	0.81	1.21	1.72	0.74	1.17	1.37

1. 1991 for Germany and Hungary, 1992 for Czech Republic, 1993 for Slovak Republic.
2. 1991 for Germany , 1992 for Czech Republic and Hungary, 1993 for Slovak Republic.
3. Western Germany before 1991.
4. Mainland only.
5. Excluding Czech Republic, Hungary, Korea, Mexico, Poland and Slovak Republic.

Source: *OECD Economic Outlook*, No 70.

Figure 1.1. **Large differentials in GDP per capita**

Percentage point difference in trend, PPP-based, GDP per capita with respect to the United States, 2000



1. Based on the ratio of working age population (15-64 years) to total population.
2. Based on employment rates and average hours worked.
3. GDP per hour worked.

Source: OECD.

rates, but this is offset by lower hours worked. By contrast, low employment rates in some countries (*e.g.* Belgium, Netherlands, France, Italy and Spain), combined with relatively low hours, explain more than 20 percentage points of the gap between their per capita income and that of the United States.

The contributions of labour productivity and labour utilisation to GDP per capita are interrelated: non-employed people of working age generally have lower education levels – and thus lower potential productivity – than those in employment. Convergence towards the US level of labour utilisation might, therefore, be associated with a drop in relative productivity in countries with low labour utilisation. Nevertheless, even if labour productivity at the margin were only half the average productivity level – a fairly conservative assumption –, rising labour utilisation in these countries would still substantially raise GDP per capita.

What drove GDP per capita growth in the 1990s?

A useful way of viewing growth in GDP per capita over the past decade is to break it down into three major components, comprising growth rates of: *i)* the ratio of persons of working-age (15-64 years) to the total population; *ii)* the ratio of employed persons to the working age population (the "employment rate"); and *iii)* labour productivity (Figure 1.2).

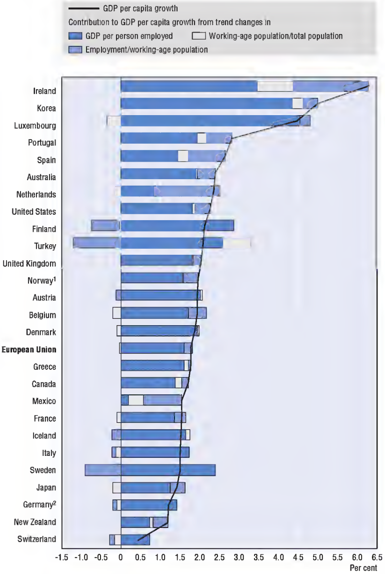
For the vast majority of OECD countries, demographic trends were a relatively minor component of growth in GDP per capita over the 1990s. The only countries where demographic change made a positive and significant contribution to growth in GDP per capita were Mexico, Korea, Turkey and Ireland, the latter having experienced a reversal in traditional migration flows in the 1990s (OECD, 1999c). However, in some OECD countries, demographic trends have begun (in this accounting sense) to act as a slight drag on growth in GDP per capita. This tendency is set to strengthen in the future due to more rapid increase in the share of older persons in total population (OECD, 1998).

Rising labour productivity, defined as GDP per person employed, accounted for at least half of GDP per capita growth in most OECD countries over the 1990s. Since hours worked fell in most countries over the 1990s, especially in continental Europe, labour productivity growth was higher on an hourly basis than when measured on a head-count basis. Declines in hours worked reflect both shorter statutory (or collectively agreed) working weeks as well as, especially in a number of European countries, a substantial increase in part-time work.[5]

Compared with the previous decade, hourly labour productivity picked up in a number of countries, including the United States, Australia, Norway, Portugal, Germany, Finland and Sweden, while it declined in the other countries. However, these changes in productivity trend were accompanied by

Figure 1.2. **The driving forces of GDP per capita growth**

Trend series, average annual percentage change, 1990-2000



1. Mainland only.
2. 1991-2000.
Source: OECD.

different employment patterns across countries. Amongst the G-7 economies, significant employment increases in the United States (as well as in Canada and Japan with no acceleration in productivity) contrasted sharply with declines in Germany and Italy. Even stronger contrasts in employment patterns were found amongst some smaller countries; strong upward trends in employment rates in Ireland, the Netherlands and Spain compare with declines in Finland and Sweden and Turkey.[6]

1.2. The role of skills and labour utilisation in labour productivity growth

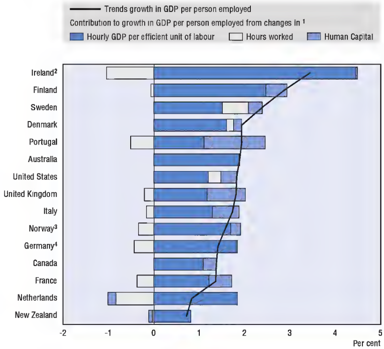
Growth in output per employed person is partly attributable to increases in the average level of skills, or "human capital", of those in employment. This is illustrated in Figure 1.3, which displays the impact of changes in the average human capital of workers on growth in cyclically adjusted GDP per hour worked. The human-capital adjustment is based on a measure of labour input that sums up shares of workers with different levels of formal education, each weighted by their relative wage. The rationale behind this measure is first that educational attainment accounts for a good proportion of human capital embodied in workers; and second, that relative wages between different levels of education provide a reasonable quantitative proxy for the relative productivity of workers with different levels of education (see Box 1.2).[7]

OECD countries have invested heavily on education over past decades and this, at least from a pure accounting perspective, resulted in a positive contribution of human capital enhancement in growth rates of GDP per person employed.[8] Over the past decade, skill upgrading amongst workers was particularly marked in Europe, where it was accompanied by sluggish employment growth, productivity gains having been achieved in part by dismissals or not employing workers with low skills.[9] By contrast, in the United States, Australia, Canada, the Netherlands and New Zealand, skill upgrading has played, at best, a modest role in GDP growth per employed person: improving labour-market conditions in these countries has widened the employment base, especially in the 1990s, allowing low-skilled workers to get a foothold in employment.[10]

In order to shed further light on this, Figure 1.4 plots changes in the share of persons in employment with upper-secondary education or above against changes in their share in the total working-age population. Up-skilling among the employed is largely associated with a generalised improvement in the educational level of the working-age population (*i.e.* countries lie close to the diagonal in Figure 1.4). Nevertheless, there has been a tendency for employment gains to be biased towards the better educated in a number of European countries (*i.e.* they are located above the diagonal). By contrast,

Figure 1.3. Enhancements in human capital contribute to labour productivity growth

Average annual percentage change, 1990-2000



1. Based on the following decomposition: growth in GDP per person employed = (changes in hourly GDP per efficient unit of labour) + (changes in average hours worked) + (changes in human capital).
2. 1990-1999 for Ireland.
3. Mainland only.
4. 1991-2000 for Germany.

Source: OECD.

some of the countries that maintained favourable labour-market conditions or experienced significant improvements have had a more balanced relative employment performance (they tend to be located at or below the diagonal in Figure 1.4).

1.3. The role of information and communication technology

Before drawing any firm conclusion on the driving forces behind OECD growth patterns, it is important to consider the process of accumulation in physical capital and technological progress. In particular, much of the recent discussion about growth has focused on the role of information and communication technology (ICT). Schematically, three main channels can be

Box 1.2. **Estimating changes in the quality of factor inputs: the example of the labour input**

In order to assess the impact of the labour and capital inputs in output and productivity growth rates, proper account should be taken of the role that each factor plays as input in the production process. In the case of labour input, the simple count of hours worked is only a crude approximation, insofar as workers show great differences in education, experience, sector of activity and other attributes which greatly affect their marginal productivity. In particular, a measure of labour input in efficiency units can be obtained by weighting different types of labour by their marginal contribution to the production activity in which they are employed. Since these productivity measures are generally not observable, information on relative wages by characteristics is used to derive the required weights to aggregate different types of labour. The difference between the weighted and un-weighted series yields an index for the compositional change of labour input, or its quality.

To take into account the effect of changes in the composition of labour input, six different types of workers were considered, based on gender and three different educational levels: below upper-secondary; upper-secondary and tertiary education. It is assumed that: *i)* workers with different levels of education work the same (average) number of hours; and *ii)* relative wage rates are constant over the sample period. Compared with other proxies available in the literature (largely for the United States) this decomposition is rather crude, but it does shed light on the role of compositional changes in labour input consistently for a range of OECD countries, thereby permitting cross-country comparisons. For more details on this procedure, see Annex 1.

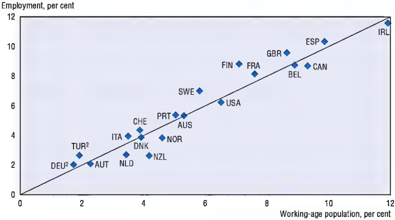
identified through which ICT can affect potential growth rates: *i)* an acceleration of productivity in the ICT-producing sectors themselves, and a growing size of ICT-producing sectors in the economy; *ii)* capital deepening across the economy, driven by rapid investment in ICT equipment, and resulting in a boost to labour productivity; and *iii)* widespread spillover effects on productivity arising from IC technology. This section focuses on the first two contributions of ICT, while the third is discussed in the next section in the broader context of the analysis of MFP trends.

The ICT-producing sector

Figure 1.5 shows the share of the ICT sector in total value-added of the business sector in a group of OECD countries.[11] In 1999, the ICT sector

Figure 1.4. **Disparities in human capital enhancement amongst employed workers and the working age population**

Percentage point change of the share of individuals with higher educational levels[1] in total, 1990-2000

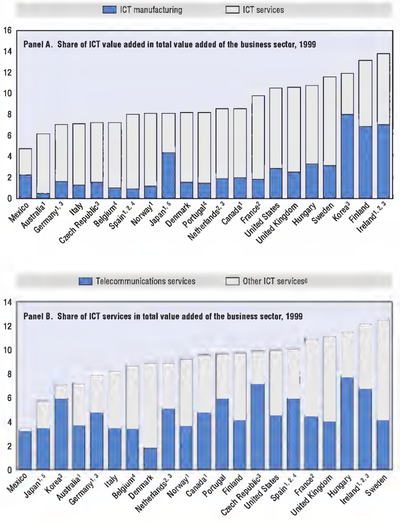


1. Higher education levels refer to ISCED codes 5, 6 and 7.
2. 1991-2000.
Source: OECD, *Education at a Glance*, various issues.

accounted for over 13 per cent of value-added of the business sector in Finland and Ireland while in several countries the sector accounted for less than 8 per cent. The composition of the ICT sector also varies across countries. While the share of telecommunications in total business sector value-added is rather similar, most of the overall differences in the size of ICT is accounted for by manufacturing industries (relatively large in Korea, Japan and Finland) and ICT services (relatively large in United States, United Kingdom, Norway and Sweden).

In the United States, the ICT-producing industry experienced a major surge in productivity in the latter part of the 1990s. Notwithstanding the small share of ICT in total value added, this within-sector acceleration is estimated to have raised annual whole-economy labour productivity growth by 0.2 to 0.3 percentage points in the 1995-99 period, compared with the first part of the 1990s.[12] There is also some preliminary evidence of accelerating productivity in the ICT-producing sector in other countries.[13] In assessing this evidence, it should be stressed that some countries may be underestimating quality improvements in ICT goods (see Box 1.3). Bearing this in mind, industrial statistics confirm that labour productivity in the two sectors most heavily engaged in the production of ICT equipment (office, accounting and computing equipment; and radio, television and communications) typically

Figure 1.5. **Different size of the ICT industry across OECD countries**



1. 1998.
2. Postal services included with telecommunications services.
3. ICT wholesale (ISIC Rev3: 5150) and rental of ICT goods (ISIC Rev3: 7123) are not available.
4. ICT wholesale (ISIC Rev3: 5150) is not available.
5. Includes only part of computer related activities (ISIC Rev3: 72).
6. "Other ICT services" is the sum of ISIC Rev3: 5150 and ISIC Rev3: 7123.

Source: OECD, *STI Scoreboard* 2001.

rose significantly faster than in the manufacturing sector at large, especially in the latter part of the 1990s (Table 1.2).

Table 1.2. **Rapid labour productivity growth in ICT industries sectors, 1999**

Over the period 1995 to 1999, 1995 = 100

	Office, accounting and computing equipment	Radio, television and communications equipment	Manufacturing
United States	364	179	126
Japan	..	112	104
Germany	226	121	118
France	..	157	116
United Kingdom	154	133	103
Canada	98	142	103
Austria	111	126	129
Denmark	95	134	111
Finland	125	209	123
Korea	433	314	148
Mexico	125	126	119
Portugal	..	174	122

Source: OECD (2000), *Indicators of Industrial Activity*, No. 4.

ICT investment and capital deepening

The second channel through which ICT affects output and labour productivity goes *via* the accumulation of physical capital. Technological progress has manifested itself, in part, through falling prices of ICT equipment (especially when adjusted for quality, see Box 1.3 below). When appropriate adjustment is made for quality improvements, annual declines in prices of IT equipment typically exceeded 10 per cent over the past decade, and were often greater than 20 per cent in the most recent years. At the same time, prices of communications equipment and software have also shown declines, albeit less marked, ranging from 1 to 4 per cent in most recent years. The falling prices have not only induced substitutions from other assets to ICT equipment, but also increased the overall level of investment (*i.e.* generated *capital deepening*) and thereby raised labour productivity.

ICT has certainly had an impact on investment patterns across OECD countries. Over the 1990s, the share of ICT equipment and software in total investment rose steadily, accounting for more than 25 per cent of total non-residential gross fixed capital formation in the United States and Finland in 2000, while in the other countries it ranged from around 15 to 23 per cent

Box 1.3. **Price measurement issues in ICT goods**

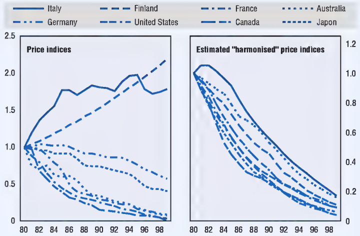
The rapid pace of technological advance in the computer industry complicates the task of splitting nominal changes into volume and price developments. The ability of a "standard" personal computer to process, store and send information has risen dramatically in the past 10-15 years. Over the 1990s the standard microprocessor speed increased 16-fold, and both the standard storage capacity and transmission speed rose by more than 200 times. With all these quality changes in the basic personal computer, it is difficult to equate one unit today with one unit a decade ago, or with an even more distant relative. There were striking developments also in the price/quality characteristics of telecommunications equipment.

Different methods are applied to measure price and quantity developments in computer production and spending (see also Colecchia and Schreyer, 2002; and Pilat and Lee, 2002)). They range from no effort to adjust for quality changes, over judgmental approaches to more complete quality adjustments with "hedonic" and similar methods. When no adjustment is made, the price index is computed from the price per computer unit, and the quantity index is based on the number of units produced or sold. The "hedonic" method unbundles the market price of the computer into its most important technical characteristics, and prices each characteristic separately, using a regression analysis approach. In other words, the regression assumes that the observed price of a given good is a function of a set of technical characteristics plus year dummies, and the "hedonic" price index is obtained by setting constant these characteristics over time. As an example, the left Panel of the Figure below shows large discrepancies in the expenditure price indexes of computers across countries. In particular, the sharp measured drop in prices of such goods in the United States reflects the use of "hedonic" methods. By contrast, the modest fall, or even increases, in many European countries may be due to the predominant "conventional" methods in deriving price indices.

In this section, "harmonised" price deflators are used for ICT equipment. They are derived by assuming that the ratios of ICT and non-ICT prices evolve similarly across countries, using the United States as the benchmark. For more details on the calculation of these harmonised price deflators see Colecchia and Schreyer (2002).

Box 1.3. **Price measurement issues in ICT goods** *(cont.)*

Price indexes for computers: a crucial issue for international comparability



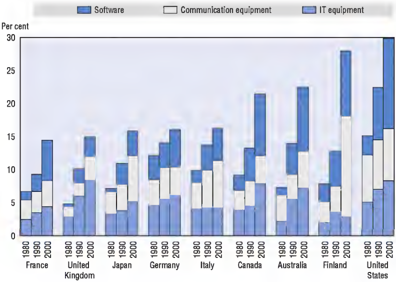
Note: Index 1980 = 1.
Source: Colecchia and Schreyer, 2002.

(Figure 1.6). Considering the different sub-components, IT and communications equipment investment rose steadily in most countries over the past decade, but was outpaced by the surge in software investment in some of them (*e.g.* United States, Canada, Australia and Finland). Moreover, also because of the rapid decline in their prices, volumes of IT capital investment rose at annual rates above 20 per cent in all countries for which data are available over the second half of the 1990s, while communications equipment and software investment rose at a strong, but somewhat lower pace, in most countries.

The strong expansion of the capital stock as a result of investment in ICT has made a rising contribution to overall output growth.[14] In the second half of the 1980s, ICT capital (IT, communication and software) accounted for only about 0.2-0.5 percentage points per year of business-sector output growth (Figure 1.7). The ICT contribution to output growth was still relatively small in the 1980s in several countries, albeit increasing at a high pace, because the ICT capital accumulation still applied to a small base. However, during the second half of the 1990s, the contribution of ICT capital to output growth increased in

Figure 1.6. **The rise in ICT investment**

Percentage share of ICT investment in total non-residential investment, current prices, 1980-2000



Source: OECD, Colecchia and Schreyer (2002).

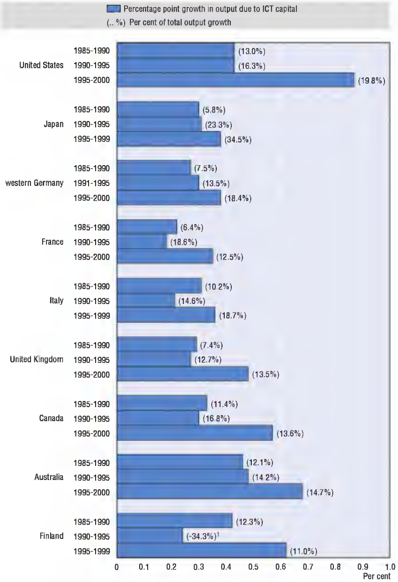
most countries, particularly in Australia, Canada, and especially the United States, where it reached 0.9 percentage points per year and accounted for about 20 per cent of total output growth.

1.4. Multi-factor productivity growth

In addition to the effects of ICT on output and labour productivity *via* the production and use of capital goods, ICT equipment can generate spillover or "network" effects in the economy. For example, the economic benefits of improved business-to-business communication via Internet do not all arise directly from quality improvements in the stock of individual computers, but also from different – and cheaper – ways of organising production and sales (*i.e.* some gains are "disembodied"). These network effects and other disembodied aspects of technological change can, in theory, be detected in estimates of MFP growth. This concept represents the residual output growth once the direct contribution of changes in the quantity and quality of capital and labour are accounted for. In practice, however, such a clear definition of MFP is difficult to apply for at least two reasons: *i)* quality and compositional changes in the capital stock are difficult to identify, at least in this

Figure 1.7. **ICT capital has boosted GDP growth**

Business sector, based on harmonised ICT price index



1. Total output growth = -0.7.

Source: OECD, Colecchia and Schreyer (2002).

international comparison (see Box 1.4), and are partially left in the productivity residual; and *ii)* for a number of countries, available data do not allow the assessment of the direct or indirect effects of ICT (nor other compositional/quality changes in capital) but, again, these are captured by the productivity residual.

Following these arguments, Table 1.3 presents different measures of cyclically adjusted MFP growth rates in the business sector of nine countries over the past decades.[15] The first measure is computed considering aggregate hours worked and gross capital stock as inputs (*i.e.* not adjusted for changes in the quality of labour and capital inputs). This is the broadest measure of productivity growth that incorporates the effects of progress in human capital as well as embodied (in physical capital) and disembodied technological progress. The second measure corrects for the general rise in education levels by using a quality-adjusted measure of labour input. Finally, the third measure of the residual also takes into account changes in the "quality" and composition of the capital stock input (see Box 1.4). This measure can be considered as a proxy for the truly disembodied technological progress, although the decomposition of capital assets is still very limited and, therefore, does not capture shifts occurring at a finer level of disaggregation. For other OECD countries, only the first measures of MFP could be calculated (see Figure 1.8).

Comparisons of the different MFP estimates in Table 1.3 indicate significant variation amongst the G-7 countries, Australia and Finland. The United States, Canada and Australia recorded a recovery in MFP growth in the 1990s that reversed a longstanding downward trend. Conversely, all measures of MFP growth rates decreased significantly in Germany, France and Italy.

The correction for changes in the composition of labour and capital inputs tends to reduce measured MFP, insofar as part of the output growth is assigned to improvements in the quality of factors used in the production process (*i.e.* embodied in inputs) rather than to changes in productivity. In the United States, contributions of human capital and quality-driven ICT-capital deepening were limited to about 0.2 percentage points in the early 1980s. However, while the role of human capital enhancement is unchanged, the contribution of ICT to embodied technological progress (reflecting the difference between the growth rate of quality-adjusted MFP and the other measures) has increased over time to peak in the second half of the 1990s, as a result of a faster pace of ICT adoption. Hence, the spread of ICT in the United States seems to have first emerged as disembodied MFP growth (probably in the ICT-producing sector) but, more recently, it has also emerged in technological progress embodied in new ICT equipment used in many sectors (see also Oliner and Sichel, 2001). Similar patterns are also observed in Finland

Box 1.4. Measures of multi-factor productivity (MFP)

Estimates of multi-factor productivity (MFP) growth are often used to proxy technological progress. They are obtained as the residual output growth once the weighted contributions of changes in capital and labour inputs are accounted for. Therefore, MFP growth estimates involve a number of assumptions concerning the measurement of output and input. In the case of labour, changes in skills and educational attainment need to be explicitly taken into account (see above). In the case of capital, quantities and prices should be adjusted for changes in quality. Moreover, measures of growth rates of MFP can be sensitive to aggregation methods. This may be the case particularly when quantities and user costs of some disaggregated inputs evolve along different patterns than those of the corresponding aggregate input. This is the case, for example, when quality improvements in some particular capital inputs (such as ICT) are faster than those in others.

A measure of MFP growth that fully accounts for changes in the composition and quality of both labour and capital inputs captures disembodied technological and organisational improvements that increase output for a given amount of inputs. However, it may also be interesting to assess the extent to which improvements in the quality of capital and labour have boosted productivity in industries and countries that have invested in them. For example, the shift towards ICT assets, whose relative prices have been falling, implies that with the same amount of resources it is possible to acquire a greater amount of productive capital services. This suggests that there is also an "embodied" element of technological change due to the expansion of the productive capacity from the shift toward ICT assets (see Greenwood *et al.* 1997, Hercowitz, 1998 for a discussion of this issue).[1]

The weighting of factor inputs in the calculation of the MFP growth residual also involves some measurement problems. In theory it should correspond to the marginal productivity of labour and capital. However the latter are not directly observable and a standard choice in the literature is to assume them to be equal to income shares, given that the labour share can be easily computed from national accounts. This corresponds to making a few assumptions, most importantly that the product and input markets are perfectly competitive and that there are constant returns to scale (Morrison, 1999). Furthermore, it is often assumed that elasticities are constant across the whole period of observation (implicitly making the assumption of unit elasticity of

Box 1.4. **Measures of multi-factor productivity (MFP)** *(cont.)*

substitution between factors) and equal to the observed average. Alternatively it can be recognised that elasticities can vary significantly for reasons other than measurement errors and as a discrete time approximation, the simple average of factor shares for each couple of subsequent years can be used. This is the approach used in this chapter. For a sensitivity analysis of the estimates obtained with this approach and those obtained using elasticities estimated econometrically, see Scarpetta *et al.* (2000).

1. As suggested by Bassanini *et al.* (2000), a proxy for total (embodied and disembodied) technological change can be computed as the residual from a growth accounting exercise in which the standard measure of capital stock (deflated at real acquisition prices) is used, instead of the measure of capital service that incorporates changes in both quality and composition. Quality changes only refer to the ICT assets and are proxied by the differences in growth rates of hedonic and non-hedonic price indexes of ICT. Composition and quality effects are estimated by considering seven types of capital goods (Colecchia and Schreyer, 2002). See Annex 1 for more details.

and Australia, where the boost to productivity from ICT adoption is one of the strongest amongst the countries reported in the table.

Given data limitations, the comparison of MFP growth rates for a wider set of OECD countries has to rely on the broader measure that incorporates changes in human and physical capital (Figure 1.7). In addition to the countries mentioned above, Denmark, Ireland, New Zealand, Norway and Sweden experienced an increase in their average growth rates of MFP (in most cases from relatively low rates in the 1980s).

It should be stressed that the context in which the acceleration in MFP growth rates has taken place differs across countries and needs to be clarified. In the case of Australia, Canada, Ireland, New Zealand, Norway and the United States, the acceleration in MFP growth has gone hand-in-hand with high, and often rising, labour utilisation and rapid GDP per capita growth. In contrast, in Finland and especially Sweden, increases in MFP growth rates have been accompanied by a slow-down in GDP per capita growth rates and significant falls in employment rates. In these latter cases, severe macroeconomic crises in the early 1990s most likely led to cleansing the least productive activities with major employment losses, but also with an increase in the recorded average MFP growth. Hence, their pattern of MFP growth not only reflects an acceleration of technical change, but also a one-shot reduction of inefficiencies.

Finally, available data do not allow a clear identification of spillover effects (*i.e.* a boost to disembodied technological progress) in ICT-using sectors, reflecting measurement difficulties as well as the fact that most

Table 1.3. **The role of embodied and disembodied components of multi-factor productivity growth**

Average annual growth rates, in per cent, business sector, 1980-2000

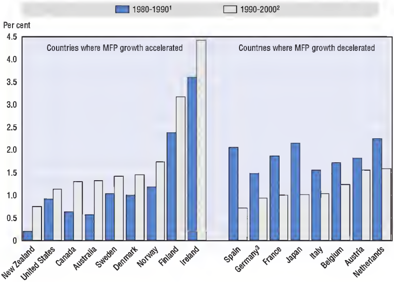
		United States	Japan	Germany[1]	France	Italy	United Kingdom	Canada	Australia	Finland
Broad measure	1980-1985[2]	0.82	1.92	1.16	2.02	1.53	..	0.49	0.68	2.47
(technical change +	1985-1990[3]	1.03	2.38	1.82	1.71	1.57	1.01	0.77	0.46	2.33
human capital)	1990-1995[4]	0.96	1.24	1.05	0.93	1.23	0.66	1.00	1.19	2.74
	1995-2000[5]	1.31	0.74	0.84	1.09	0.80	0.96	1.61	1.47	3.58
Adjusted for human capital	1980-1985[2]	0.67	..	1.15	1.83	1.50	..	0.32	0.69	2.21
(embodied + disembodied	1985-1990[3]	0.87	..	1.82	1.36	1.38	0.66	0.60	0.46	1.99
technical change)	1990-1995[4]	0.79	..	1.07	0.45	0.76	0.05	0.79	1.13	2.35
	1995-2000[5]	1.15	..	0.87	0.67	0.34	0.32	1.41	1.32	3.26
Fully adjusted	1980-1985[2]	0.46	..	1.01	1.67	1.33	..	0.12	0.47	2.02
(disembodied technical change)	1985-1990[3]	0.65	..	1.65	1.18	1.19	0.47	0.40	0.18	1.79
	1990-1995[4]	0.50	..	0.88	0.27	0.59	–0.16	0.57	0.80	2.10
	1995-2000[5]	0.75	..	0.66	0.48	0.16	0.07	1.13	0.97	2.90
Memorandum item:	1980-1985[2]	0.20	0.14	0.14	0.16	0.17	..	0.20	0.22	0.19
embodied technical change	1985-1990[3]	0.22	0.20	0.17	0.18	0.19	0.20	0.21	0.28	0.19
	1990-1995[4]	0.29	0.23	0.19	0.18	0.17	0.21	0.22	0.33	0.26
	1995-2000[5]	0.40	0.23	0.22	0.20	0.19	0.25	0.28	0.35	0.38

1. Western Germany before 1991.
2. 1982-1985 for Finland.
3. 1987-1990 for the United Kingdom.
4. 1991-1995 for Germany.
5. 1995-1997 for the United Kingdom,1995-1999 for Australia, France, Italy and Japan.

Source: OECD.

Figure 1.8. **Multi-factor productivity growth accelerated in some countries**

Business sector, based on cyclically-adjusted series, 1980s and 1990s



1. 1983-1990 for Belgium, Denmark and Ireland, 1985-1990 for Austria and New Zealand.
2. 1990-1996 for Ireland and Sweden, 1990-1997 for Austria, Belgium and New Zealand, 1990-1998 for Netherlands, 1990-1999 for Australia, Denmark, France, Italy, Japan and 1991-2000 for Germany.
3. Western Germany before 1991.

Source: OECD.

innovative ICT-based businesses and markets are still at an early stage of development (Box 1.5).

1.5. Concluding remarks

The review of aggregate growth patterns in this chapter suggests widening disparities in GDP per capita growth rates across the OECD countries over the past decade, also after abstracting from cyclical influences. These disparities are driven by higher than average growth rates in some catch-up countries (*e.g.* Korea and Ireland), but also by high growth rates in some relatively affluent countries, such as the United States, Canada, Australia, the Netherlands and Norway, and low growth rates in much of continental Europe and Japan. Reflecting these growth patterns, over the 1990s the United States began to pull away from most other countries in terms of GDP per capita levels. This happened despite some continued – albeit slight – convergence in aggregate labour productivity levels.

Box 1.5. **Problems associated with assessing spillover effects in ICT-using sectors**

The identification of spillover effects (*i.e.* a boost to disembodied technological progress) in ICT-using sectors raises two main difficulties. First, there are serious problems associated with the recording of output in some of the industries using ICT most intensively. For example, measurement of the output of banks and financial institutions, which are heavy users of information technology, is generally regarded as poor, and any productivity-raising effects of computers in these sectors could go largely unrecorded in national accounts.[1]

Second, it is difficult to assess the impact of innovative ICT-based businesses and markets, most of which are at an early stage of development. For example, any productivity gains from business reorganisation to take advantage of Internet and other networks are likely to become clearly visible only after a certain threshold in network use has been passed. However, there is anecdotal evidence that Internet – which became available for business only in the mid-1990s – is now producing significant changes in several parts of the economy, especially in business-to-business transactions. Businesses are taking greater advantage of better real-time information systems, rationalising costly precautionary inventory stocks and the distribution of their products. Businesses have also started to reduce costs by integrating their suppliers more closely in the design and manufacturing of products, while also using the web to outsource tasks previously carried out internally. With greater information exchange between customers and producers, companies are likely to reduce labour hoarding required to meet unanticipated increases in product demand. As regards business-to-consumer transactions, electronic commerce is still in its infancy and unlikely to have had much effect on aggregate productivity to date, but fast expansion in the future could have major effects on distribution efficiency and work to strengthen competition, with beneficial effects on productivity as well as on consumer choices (Coppel, 2001). This suggests that the bulk of spillover effects stemming from the use of ICT may be yet to come.

1. For several sectors, measurement problems obscure a substantial part of the productivity gains (Gullickson and Harper, 1999). Fixler and Zieschang (1999), for example, derive new output measures for the US financial services industry (*i.e.* depository institutions). They introduce quality adjustments to capture the effects of improved service characteristics, such as easier and more convenient transactions and intermediation. The output index calculated in this study grew by 7.4 per cent a year between 1977 and 1994, well above the GDP measure for this sector that grew only by 1.3 per cent a year on average. The recent revisions of GDP growth by the US Department of Commerce incorporate improved estimates of the real value of unpriced banking services, thus better capturing productivity growth in this industry (Moulton, Parker and Seskin, 1999; BEA, 1999).

The evidence presented in this chapter suggests that cross-country disparities are, at least partially, related to differences in the patterns of labour utilisation and skill upgrading of the workforce. In particular, most of the countries that experienced an acceleration in GDP per capita growth also recorded an increase in labour utilisation, while most of those where employment stagnated, or even declined, saw a deterioration in their growth performance. This is because in these countries, labour productivity growth has not been able to offset the negative contribution to growth coming from poor employment performance. Furthermore, in most countries the up-skilling of the workforce played a significant role in boosting labour productivity but, in those with poor employment performance, this was partially due to the fact that the-low skilled were kept out of work.

There are also some new factors behind the observed disparities in growth performance across the OECD countries, largely related to the spread of ICT. In particular MFP, taken as a proxy for technological change, accelerated in a number of OECD countries, most notably in the United States and Canada, but also in some small economies (*e.g.* Australia, Ireland). The contribution of ICT to aggregate MFP growth was initially "disembodied", resulting from rapid technological progress within the ICT-producing industry. Since the mid- to late-1990s, an increasing contribution to (embodied) productivity growth seems to result from greater use of highly productive ICT equipment by other industries. Not surprisingly, MFP growth accelerated somewhat later in those OECD countries without a sizeable ICT-producing industry.

All in all, growing disparities in growth trends over the past decade seem to result from a combination of "traditional" factors – mostly related to the efficiency of labour market mechanisms – and "new economy" elements reflecting the size of the ICT-producing industries, but also the pace of adoption of this technology by other industries. This evidence raises the question as to whether policy and institutional settings, by contributing to shaping business conditions for existing firms and new entrepreneurial activities, have a role to play in explaining the different ability of countries to innovate in expanding industries and to adopt leading technologies.

Notes

1. This chapter draws on a number of recent OECD studies including: Scarpetta *et al.* (2000); Bassanini *et al.* (2000); OECD (2000); and Colecchia and Schreyer (2002).
2. Given the large scale of the revision associated with the shift to the new SNA, its implementation has been gradual, with progress from old to new methods being uneven across countries, across series within a country, and over different time horizons. This book uses data provided by the national authorities and included in the Analytical Data Base (ADB) of the OECD, which takes into account changes in the new System of National Accounts. See Annex 1 for more details.

3. See Box 1.3 for details.
4. Strictly speaking, per capita GNP growth would be an even better measure but, in practice, there is little difference between the two concepts in cyclically adjusted growth rates terms (see Scarpetta *et al.*, 2000 for more details).
5. Strong growth in part-time working has generally been associated with a growing female labour-force participation (OECD, 1999b).
6. It should be noted however that the declines in Finland and Sweden were from relatively high employment rates at the end of the 1980s.
7. This assumption, necessary for the quantitative analysis, is common in the literature even if it is certainly rather strong. It implies that firms operate under constant returns to scale in competitive input and product markets and maximise their profits by setting output and employment at a level where the marginal product of labour is equal to the marked determined wage. The Bureau of Labor Statistics (BLS, 1993) discusses how deviations from these hypotheses affect the relationship between the contribution to output and compensation.
8. The result for Germany is partly the result of the unification with the Eastern Länder where the average level of education was lower than in the Western Länder. In the case of both Ireland and the Netherlands, the widening of the employment base (including the increased employment amongst the low skilled) is largely responsible for the small or even negative estimated effect of changes in human capital to productivity growth.
9. From the discussion in the previous paragraph, skill upgrading should be interpreted as a shift in the composition of the workforce towards better-educated workers, and not as an improvement of individual workers' human capital.
10. This, together with the way skill upgrading is measured (see the above footnote), explains the negative contribution of human capital to labour productivity growth shown in Figure 1.3 for the Netherlands and New-Zealand.
11. The ICT sector includes industry classes within *manufacturing*, *telecommunications* and *other ICT services*, which mainly comprises all *computer and related activities* and *wholesale machinery, equipment and supplies*. For more details on the composition of the ICT sector see OECD, "Measuring the ICT Sector", 2000.
12. See Gordon (2000); Oliner and Sichel (2001); Council of Economic Advisors (2000).
13. See Pilat and Lee, 2001 for further details.
14. The contribution of ICT capital to output growth is the product of three components: *i)* the share of total capital in total income; *ii)* the share of ICT capital in total capital; and *iii)* the rate of growth of ICT capital.
15. These are obtained by using cyclically adjusted series for all the components of the growth accounting.

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The Sources of Economic Growth in the OECD Countries

Chapter 2

Policy Settings, Institutions and Aggregate Economic Growth: a Cross-country Analysis

Abstract. *This chapter[1] sheds some light on the possible policy determinants of the observed growth disparities across the OECD countries discussed in the previous chapter. In addition to the "primary" influences of capital accumulation and skills embodied in human capital, the econometric analysis confirms the importance for growth of R&D activity, the macroeconomic environment, trade openness and well-developed financial markets. The empirical results also confirm that many of the policy influences operate not only "directly" on growth but also indirectly via the mobilisation of resources for fixed investment.*

Introduction

The growth patterns presented in the previous chapter raise a number of questions as to the role that policy and institutional settings may have in shaping long-term economic developments. Indeed, the increased dispersion of growth rates across OECD countries may, at first glance, seem to be at odds with the observed convergence in macro-policy settings, whereby most OECD countries have moved towards price stability and sounder medium-term fiscal policies, *i.e.* favourable framework conditions for growth. However, Chapter 1 indicated that apart from a sound macroeconomic environment, the main factors driving growth disparities are "structural", *i.e.* relating mostly to the ability of countries to employ people of working age and investing in human capital and new technologies. This finding clearly raises questions as to the role of structural policies affecting these factors – as well as those relating directly to "new economy" elements, *i.e.* the production and diffusion of ICT.

This chapter sheds some light on these issues by presenting empirical evidence on the long-term links between policy settings, institutions and economic growth in OECD countries, while controlling for underlying differences in technological progress. The focus is two-fold: first, on the possible influences of human capital, research and development activity, macroeconomic and structural policy settings, trade policy and financial market conditions on productivity; second, on the effects of many of the same factors on the accumulation of physical capital. Assessing the links between these factors and growth may also help in the assessment of the medium-term growth prospects for countries that have changed their policy settings over more recent years, and for whom the effects of these reforms may have not yet materialised.

The chapter starts (Section 2.1) with a short overview of the potential factors driving growth in the long run. The role of education, infrastructure and research is explored, as well as a number of policy and institutional factors that could influence output growth *via* their impact on the accumulation of physical capital or *via* their impact on productivity. The evidence suggests large cross-country differences along all these dimensions of direct government intervention and policy settings which, in turn, confirms the interest in linking them with growth performance. This is done in Section 2.2 on the basis of multivariate growth regressions for 21 OECD countries over the 1971-1998 period. The set of institutional and policy

variables considered have three basic characteristics: *i)* they are largely economy-wide in nature; *ii)* they yield testable implications for economic growth; and *iii)* they can be evaluated using available data across countries and over time. This set of variables is by no means exhaustive, and the empirical results do not allow precise quantitative estimation of the impact of a specific policy reform on long-run growth: rather they point to directions and approximate orders of magnitude of the potential effects. Bearing these caveats in mind, Section 2.3 discusses the potential effects of changes in policy and institutional settings for long-term output per capita and, in so doing, sheds light on the scope for reforms in OECD countries. A final section summarises the main results of this chapter.

2.1. An overview of policy influences on economic growth

The literature on economic growth is vast, and policy-oriented studies in particular, have flourished in the past decade (see Temple, 1999 and Ahn and Hemmings, 2000 for surveys). Yet, there is little agreement on the exact mechanisms linking policy settings to growth (see Box 2.1). At one extreme, if one assumes, in compliance with the traditional neo-classical growth model, diminishing returns to reproducible factors and exogenous saving rates, population growth and technological progress, then policies have no direct role in shaping long-term economic growth.[2] At the other extreme, policy may have a persistent effect on the rate of economic growth if investment in physical and human capital is considered to be endogenous and displays constant or even increasing returns to scale. In the latter case, there is no longer a process of convergence across countries, even after controlling for some country-specific factors (geographical location, natural resource endowment, etc.).

Only empirical research can provide evidence on which view of the link between policy and growth is most relevant, but results of such studies are often ambiguous. This is particularly the case if the empirical analysis focuses on OECD countries (Temple, 1999). The cross-country variability in both growth patterns and potential explanatory variables is much smaller if one focuses on the OECD sub-sample. Hence, data quality and the estimation approach assume an even more crucial role in the empirical analysis. Both issues are tackled in the chapter by using harmonised OECD data and a novel econometric approach that reconciles model assumptions with available data. By way of background, the remainder of this section briefly spells out the possible mechanisms relating a given policy or institutional factor to growth, and looks at differences across OECD countries and over time in these policy and institutional settings.

Box 2.1. **Policy settings and growth: what does theory suggest?**

Despite renewed interest in the determinants of growth, there is still no clear agreement on the mechanisms linking policy settings to growth. Under the restrictive assumptions of the traditional neo-classical growth model – *i.e.* diminishing returns to reproducible factors and exogenous saving rates, population growth and technological progress – policies have no direct role in shaping long-term economic growth. Under the extreme case in which countries have the same saving rate, technological progress and population growth, they will also share the same steady-state output growth path, and less advanced economies have higher growth rates than more advanced ones during the transition to the steady-state growth path. Failure to observe such a process of unconditional convergence across countries, especially in more recent years, has led most economists to remove some of these restrictive assumptions and consider a process of conditional convergence; that is to say, a relationship where growth rates are related to initial conditions, but only after controlling for other variables.

For example, relaxing the assumption of exogenous saving and capital formation gives room for policy to affect growth in the short- and medium-term via an impact on saving and the level and composition of investment. Indeed, a number of studies suggest that policy and institutions affect the *level* of economic efficiency with which resources are allocated in the economy. Nevertheless, whether through its effect on investment or on the level of economic efficiency, a one-time change in policy leads only to a transitory change in output growth in such models. When the capital stock and output have risen to levels at which the new rate of gross investment is only sufficient to maintain a constant capital/labour ratio plus an amount to cover physical depreciation, growth reverts back to the steady state rate. In other words, any policy influence on savings and investment affects output growth only in the short- to medium-term perspective by shifting the growth path, although the underlying long-run rate of growth (*i.e.* the slope of the path) remains unchanged.

Another class of studies relaxes the assumption of diminishing returns to capital. They assume that production requires not only physical, but also other forms of capital, which may include human capital (*e.g.* education), knowledge capital (*e.g.* R&D) and infrastructure (*e.g.* Lucas, 1988; Jones and Manuelli, 1990; Rebelo, 1991). Some of these

Box 2.1. **Policy settings and growth: what does theory suggest?** *(cont.)*

forms of capital are likely to influence the process of innovation and technological progress, thereby leading to constant (or even increasing) returns on capital (*e.g.* Romer, 1986; Young, 1991) or R&D (*e.g.* Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). For example, human capital and R&D are important ingredients in the formation of new ideas and their translation into new production processes, and technological progress itself may be embodied in new capital equipment, thus creating a link between physical capital accumulation and long-term growth rates. With constant (or increasing) returns to this extended concept of capital, the long-term rate of growth becomes endogenous, in the sense that it depends on investment decisions. Some of these endogenous growth models imply "conditional" convergence while others do not, depending on assumptions about the specification of the production function and the evolution of broad capital accumulation (see Barro and Sala-i-Martin, 1995; Durlauf and Quah, 1999 for reviews). In any event, to the extent that they can influence savings and the formation of different forms of capital, policy and institutions may have a permanent effect on output growth.

As can be seen, the distinction between these two views largely depends on how one sees the process of accumulation of various types of capital being affected by policies and how capital accumulation then feeds back into output growth. This is mainly an empirical issue, because it appears difficult to discriminate amongst the two views on an *a priori* basis.

The basic determinants of growth

The accumulation of physical capital

The rate of accumulation of physical capital (typically proxied by the share of investment in GDP) is one of the main factors determining the level of real output per capita. Its effects could be more or less permanent depending on whether there are externalities to capital accumulation, *i.e.* private returns to scale may be diminishing, while social returns may be constant or even increasing (see *e.g.* Arrow, 1962; Romer, 1986). This situation may reflect spillovers of knowledge, or other externalities. For instance, it may occur when the introduction of new capital leads to better organisation, as it helps the firm learn how to produce more efficiently (Arrow, 1962). It is also possible

that the growth rate of labour productivity of workers operating on new machines could be related to investment in new technologies (Kaldor, 1957).

Whatever the transition mechanism from capital accumulation to output and growth, the significant differences in the investment rate across OECD countries point to it as a possible source of differences in output per capita growth across countries and over time. In particular, long-run averages of business-sector investment rates range from around 10 per cent to over 20 per cent of GDP. Furthermore, major shifts in investment rates within countries are common, a notable example in the 1990s being the United States, Canada and the United Kingdom, amongst the G-7, as well as Austria, Belgium, Denmark, New Zealand and Spain (Figure 2.1).

The accumulation of human capital

Formal skills and experience embodied in the labour force can be viewed as a form of (human) capital. It could be argued that human, like physical capital, is subject to some kind of diminishing returns, so that a more highly-trained and skilled workforce would enjoy higher levels of income in the long term, but not necessarily permanently higher growth rates of income. This is the assumption made by extended neo-classical growth models to explain permanent differences in income per capita across countries.

Alternatively, investment in human capital (*e.g.* expenditures on education and training) could have a more permanent impact on the growth process if high skills and training go hand-in-hand with the process of innovation, leading to a faster rate of technological progress, or if a highly-skilled workforce eases the adoption of new technologies. Advances in technology indeed often have strong links with education, especially at the higher level. Thus, education may not only make a contribution to growth *via* "embodied" improvements in the quality of the workforce, but also a contribution *via* innovation.[3]

Available indicators of human capital typically focus on levels of formal education. They are admittedly crude and somewhat narrow proxies, taking little account of quality aspects of formal education or other important dimensions of human capital, such as on-the-job training. Nonetheless, estimates of the average years of schooling amongst the working-age population shown in Table 2.1 suggest that despite some convergence over past decades, there remain significant differences across OECD countries (see also Bassanini and Scarpetta, 2001 for more details).

Research and development

Expenditure on R&D can be considered as an investment in knowledge that can translate into new technologies and more efficient ways of using

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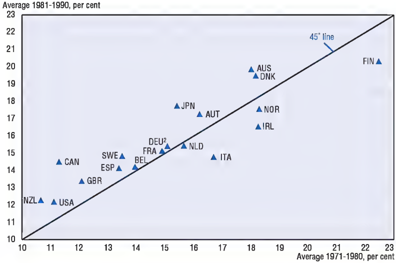
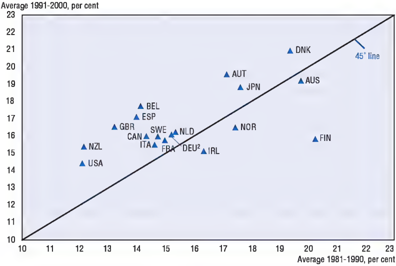
Figure 2.1. **Business-sector investment share has typically increased[1]**

Share in GDP, 1970s-1990s





1. The ratio of private non-residential fixed capital formation to business-sector GDP. The figures are cyclically adjusted using an H-P filter.
2. Western Germany before 1991.

Source: OECD.

Table 2.1. **The long-term improvement in the level of education of the population**

Average number of years of education in the working-age population[1]

	1970	1980	1990	1998
Australia	11.02	11.58	12.14	12.34
Austria	9.72	10.42	11.27	11.77
Belgium	8.16	9.26	9.78	10.79
Canada	11.37	12.10	12.47	12.94
Denmark	9.85	10.60	11.04	11.43
Finland	8.63	9.60	10.40	11.21
France	8.75	9.51	9.96	10.60
Germany[2]	9.47	11.41	12.89	13.55
Greece	7.40	7.93	8.85	9.86
Ireland	7.84	8.49	9.38	10.26
Italy	6.64	7.32	8.36	9.79
Japan	9.14	10.22	10.90	11.51
Netherlands	9.00	10.11	11.21	11.85
New Zealand	10.24	10.92	11.35	11.77
Norway	9.78	10.74	11.59	11.96
Portugal	6.51	6.90	7.23	7.73
Spain	5.71	7.22	7.32	8.65
Sweden	9.10	10.10	11.07	11.65
Switzerland	10.47	11.49	12.58	12.90
United Kingdom	9.10	10.10	10.89	11.95
United States	11.57	12.23	12.59	12.71

1. Based on data on highest level of education attained and assumptions about the number of years of education implied by different levels of education achievement.
2. Western Germany in 1970, 1980 and 1990.

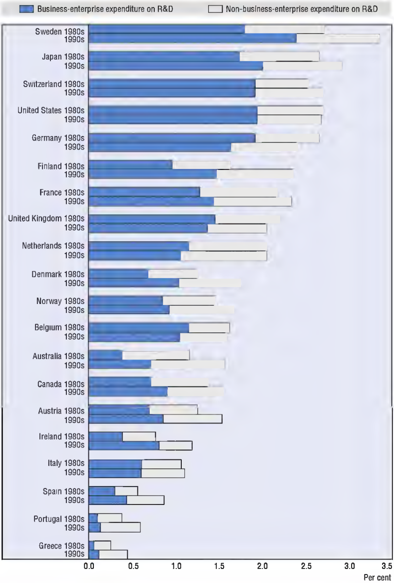
Source: OECD.

existing resources of physical and human capital. Insofar as it is successful in these respects, it is plausible that higher R&D expenditure would, *ceteris paribus*, be associated with permanently higher growth rates. The potential benefits from new ideas may not accrue fully to the innovators themselves due to spillover effects, implying that without policy intervention the private sector would likely engage in less R&D than is socially optimal. This can justify some government involvement in R&D, both through direct provision and funding, but also through indirect measures such as tax incentives and protection of intellectual property rights to encourage private-sector R&D (see Nadiri, 1993 and Cameron, 1998, for a review).

Overall expenditure on R&D as a share of GDP has risen somewhat since the 1980s in most countries, largely reflecting increases in R&D in the business sector, which accounts for the majority of expenditure in this area in most OECD countries (Figure 2.2).[4] The increase in business-sector R&D intensity has been driven by larger resources made available by private firms, rather

Figure 2.2. **Business R&D has risen, government R&D budgets have declined**

Total expenditure on R&D as a percentage of GDP, 1980s and 1990s



Source: OECD.

than by governments: indeed the share of publicly-financed business-sector R&D has declined over the past decade (see OECD, 2001d).

An important policy consideration is whether the relationship between public and private R&D is one of complementarity or substitution. Available empirical literature gives conflicting answers: a number of studies support the complementarity hypothesis, but others cite instances where publicly-funded R&D displaces private investment (see David *et al.*, 1999 for a survey and Guellec and van Pottelsberge, 2000). A final consideration with respect to the role of public-sector R&D is that it is often directed at making improvements in areas such as defence and medical research, where the impact on output growth could be diffused and slow to come about (see OECD, 1998). All in all, these considerations suggest that when taking R&D activity into account as an additional form of investment, the possible interactions between different forms of R&D expenditure and different forms of financing should also be considered.

Policy and institutional influences on growth

Macroeconomic policy setting and growth

In recent years most OECD countries have made significant steps towards low inflation and improved public finances. A number of studies have shown the effects for economic growth of these moves towards more stability-oriented macroeconomic policies to be beneficial, at least for a while. Three issues have received particular attention: the benefits of maintaining low and stable inflation, the impact of government deficits on private investment, and the possibility of negative impacts on growth stemming from a too-large government sector (with the associated heavy tax burden to finance high government expenditure).

Inflation and growth. The usual arguments for lower and more stable inflation rates include reduced uncertainty in the economy and enhanced efficiency of the price mechanism.[5] To a certain extent, inflation can be considered as a tax on investment,[6] so that low levels of inflation may reduce the profitability required to undertake an investment project, with an overall positive impact on the accumulation of physical capital. On the other hand, a lower rate of inflation may reduce the opportunity cost of holding money, thereby leading to a portfolio shift from capital to money and a decline in investment.[7] However, this effect is probably very small because money balances are only a small fraction of the capital stock.

Inflation could also have an effect on capital accumulation *via* its impact on economic uncertainty. A lower level of inflation may be associated with reduced uncertainty about inflation[8] and reduced "noise" in price signals, reflected in a smaller amount of relative price variability.[9] Reduced

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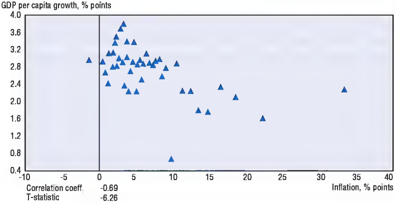
uncertainty may, in turn, result in more stable output growth and improve the environment for private sector decisions. Notably, if investment is irreversible (*i.e.* once a machine has been put in place it has no alternative use), then more stable output growth might prompt firms to raise their capital expenses.[10]

A simple comparison of inflation rates and growth rates for OECD countries shows a negative link between the level of inflation and output growth (Figure 2.3). However the strength of the link is clearly weak at low levels of inflation. There is also a correlation between the changes in variability of inflation and in average growth rates from the 1980s to the 1990s (Figure 2.4). In this latter case however, there are two clear outliers (Ireland and Greece)[11] that weaken the relationship. Excluding these two countries, a somewhat negative relationship emerges: *ceteris paribus*, countries with a significant reduction in the variability of inflation do not seem to have experienced the decline in growth that other countries have. More generally, it is necessary to control for a variety of influences on growth over and above inflation variables, most notably initial conditions that may have played a role in such countries as Ireland and Greece.

From the discussion above, it appears that the empirical analysis should consider both the level and the variability of inflation, and try to distinguish

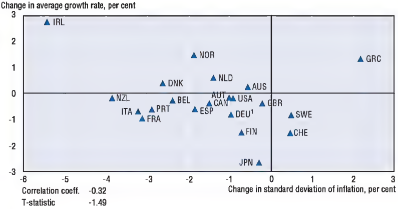
Figure 2.3. **The link between the level of inflation and economic growth**

Average growth and median inflation in equal-sized samples of annual inflation and growth data



Note: Individual observations across countries and time are first ranked by the level of inflation. These ranked observations, coupled with corresponding data on GDP per capita growth rates, were then divided into successive groups of 20 observations. The points shown in the figure represent the median inflation of each group and the corresponding average growth in GDP per capita.
Source: OECD.

Figure 2.4. **Changes in the variability of inflation and growth between the 1980s and 1990s**



1. Western Germany before 1991.
Source: OECD.

between two different effects: *i)* their potential impact on output *via* investment; *ii)* their influence on output over and above their effect on investment, in relation to their effect on resource allocation and the *ex-post* return on investment.

Fiscal policy and growth. Most types of government expenditure probably have some impact on economic growth, either directly (for example through the accumulation of capital in housing, urban infrastructure, transport and communication) or indirectly (by affecting incentives for investment in the private sector). All have to be financed. Analysing the impact of these expenditures on growth is not straightforward, in part because the mechanisms may be complex and slow to operate in some cases, but also because the causation could go the other way.[12]

Bearing these factors in mind, where public consumption or social transfers are financed by government deficits, a traditional argument for a more restrictive fiscal policy is to reduce the crowding out effects on private investment. Also, if fiscal policy is seen as being at odds with a stability-oriented monetary policy, the efficacy of the latter could be undermined, leading to risk premia in interest rates and pressures on exchange rates. Where taxes are raised to support government spending, they may distort incentives and reduce the efficient allocation of resources. At least, as suggested by neo-classical models, these distortions affect the level of output.

At most, in the presence of some forms of endogenous growth, they may have a long-lasting negative impact on the growth of output.[13] In any event, these negative effects may be more evident where the financing relies more on so-called "distortionary taxes"[14] and where public expenditure focuses on areas not directly related to growth.[15]

The bottom line from the literature is that there may be both a "size" effect of government intervention, as well as specific effects stemming from the financing and composition of public expenditure. At a low level, the productive effects of some components of public expenditure are likely to be beneficial for output growth. However, government expenditure and the required taxes may reach levels where the negative effects on efficiency start dominating, reflecting an extension of government activities into areas that might be more efficiently carried out in the private sector, and (or) misguided or inefficient systems of transfers and subsidies.

Between the 1980s and 1990s the "size" of the public sector tended to increase in most OECD countries, as did government gross liabilities (see Figure 2.5), although most recent years have seen some reversal of this trend. Notwithstanding these latter developments, in 1999 the share of total government expenditure in GDP was still in the range of 40-50 per cent in a number of OECD countries. Moreover, less than one-fifth of expenditure is typically allocated to areas more directly related to growth (*e.g.* schooling, infrastructure and R&D). And in a number of countries, the share of these "productive" expenditures declined over the past decade (Table 2.2).

Following the above discussion, the empirical analysis in Section 2.2 will consider three main aspects of the impact of fiscal policy on growth: *i)* the overall "size" effect; *ii)* the role of tax structure on the one hand and composition of expenditure on the other, by looking separately at direct and indirect taxes and considering different elements of expenditure; *iii)* the role of direct and indirect effects, by testing separately the significance of these policy variables for private investment and, more directly, for growth.

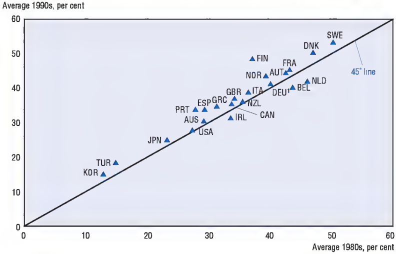
International trade and growth

Aside from the benefits of exploiting comparative advantages, theories have suggested additional gains from trade arising through economies of scale, exposure to competition and the diffusion of knowledge. Past progress in reducing tariff barriers and dismantling non-tariff barriers has almost certainly opened up opportunities to benefit from trade.

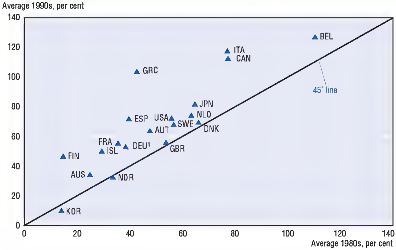
However, the relatively open stance towards trade in OECD countries would suggest that the amount of trade conducted not only depends on tariff and non-tariff barriers, but also reflects patterns of growth (and to some extent geography, size and transport costs). For this reason, the intensity of

Figure 2.5. **Total government expenditure and liabilities as a percentage of GDP**

Panel A. Total government expenditure on goods, services and transfers as a percentage of GDP, 1980s and 1990s



Panel B. General government gross financial liabilities as a percentage of GDP, 1980s and 1990s



1. Western Germany before 1991.
Source: OECD.

Table 2.2. **Total government outlays and "productive" government spending as a share of total spending**

Percentage

	A		B		C		A + B + C		Share of total government outlays in GDP		
	Education		Transport and communication		R&D						
	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995	2000
Australia	14.6	13.2	10.1	8.3	2.1[5]	2.2[4]	28.8	23.6	38.0	35.7	32.6
Austria	9.6	9.5	3.3	2.1	1.2	1.4	14.1	13.0	50.3	52.5	47.9
Belgium	12.7	. .	8.7	. .	0.9	. .	22.3	. .	57.1	50.2	46.7
Canada	13.0	. .	5.4	. .	1.5	. .	19.8	. .	45.2	45.0	37.7
Denmark	11.3	11.7	4.0	3.0	1.2	1.2	16.4	15.9	54.2[3]	56.6	49.9
France[1]	10.5	10.7	2.9	1.9	2.3	1.8	15.7	14.4	51.9	53.5	51.0
Germany	9.5	7.6	4.3	3.4	2.2	1.8	16.0	12.9	45.6	48.3	43.3
Iceland	13.0	12.3	9.0	7.6	1.6	2.5	23.6	22.4	35.3	39.2	38.5
Ireland[1]	10.6	12.2	4.5	5.0	0.8	0.8	15.9	18.0	50.7	38.0	29.3
Italy	10.0	8.9	7.7	4.6	1.2	1.0	18.8	14.5	49.7	51.1	44.4
Japan	12.8	10.8[4]	. .	. .	1.8	1.9	. .	. .	29.4	34.4	36.6
Korea	17.8	18.1	7.1	9.6	. .	2.7	. .	30.4	17.6	19.3	23.1
Netherlands	9.9	. .	. .	. .	1.8	. .	. .	. .	51.9	47.7	41.6
New Zealand	. .	13.3[4]	. .	. .	. .	1.3[1]	. .	. .	51.8[6]	38.8	38.6
Norway	12.0[3]	13.7	6.6[3]	5.9	1.6	1.6	20.2	21.3	41.5	47.6	40.8
Portugal[2]	8.7	13.3	3.6	4.8	0.5[5]	0.9	12.9	19.0	39.9	41.3	40.8
Spain	8.8	10.3	6.3	6.0	0.7	0.9	15.8	17.1	39.7	44.0	38.8
Sweden	. .	. .	. .	. .	1.7	1.7	. .	. .	60.4	61.9	52.7
Switzerland	19.7	. .	11.4	. .	. .	. .	. .	. .	. .	. .	. .
United Kingdom	10.2	12.1	3.2	3.6	2.0	1.5	15.5	17.2	40.5[7]	42.2	37.0
United States	. .	. .	. .	. .	4.1	2.8	. .	. .	33.8	32.9	29.9

1. 1993 instead of 1995.
2. 1992 instead of 1995.
3. 1988.
4. 1994.
5. 1984.
6. 1986.
7. 1987.

The concept of "productive" government spending is based on a taxonomy used by Barro (1991).

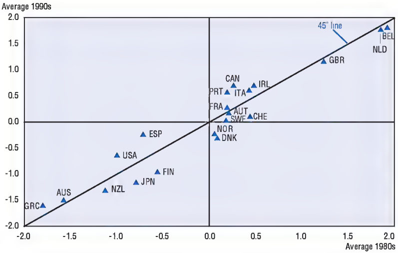
Source: OECD.

trade in the empirical analysis below should be considered more as an indicator of trade exposure – capturing features such as competitive pressures – rather than one with direct policy implications. Apart from bearing this caveat in mind, the empirical analysis also has to take into account the fact that small countries are naturally more exposed to foreign trade, regardless of their trade policy or competitiveness, while competitive pressure within large countries stems, to a great extent, from domestic competition. To better reflect overall competitive pressures, the indicator of trade exposure was adjusted for country size by regressing the crude trade exposure variable on population size and taking the estimated residuals from this exercise as the (adjusted) trade variable in the analysis.

Figure 2.6 plots country differences in this "corrected" measure of trade exposure and its evolution over the past decade. As expected, although significant differences remain across the board, exposure to foreign trade has increased in some OECD countries, possibly fostering technological spillovers and growth, *ceteris paribus*.

Figure 2.6. **Greater exposure of several OECD countries to foreign trade**

Size-adjusted exposure to foreign trade, 1980s and 1990s



Note: The indicator of exposure to foreign trade is a weighted average of export intensity and import penetration, adjusted for country size (*i.e* it is the residual from the regression of the weighted average of export intensity and import penetration on population size). The data reported in the figure are standardised to ease cross-country comparison.
Source: OECD.

Financial development and growth

Financial systems play a role in the growth process because they are key to the provision of funding for capital accumulation and the diffusion of new technologies. A well-developed financial system: *i)* mobilises savings, by channelling the small-denomination savings of individuals into profitable large-scale investments, while offering savers a high degree of liquidity; *ii)* provides insurance to individual savers against idiosyncratic risk through diversification; *iii)* reduces the costs of acquiring and evaluating information on prospective projects, for example through specialised investment services; and *iv)* serves in the monitoring of investments to reduce the risk of resource mismanagement. All these services are likely to contribute to economic growth but there could, in theory, also be opposite effects. For example, lower risk and higher returns resulting from diversification may prompt households to save less.

Ideally, one would like to use qualitative indicators of the possibilities offered to firms to access external funds and the ease with which investors can get adequate returns. However, available information is only limited to quantity indicators (Leahy *et al.*, 2001). In particular, two indicators are considered: *i)* total claims of deposit money banks in the private sector, which measures the degree of financial intermediation via the banking system; and *ii)* stock market capitalisation (the value of listed shares), which is an imperfect indicator of the ease with which funds can be raised on the equity market.[16] Both indicators point to a significant development in financial systems of most OECD countries between the 1980s and the 1990s (Figure 2.7).

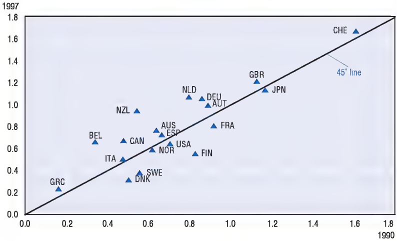
2.2. Econometric evidence on the links between investment, policy settings and growth

In order to assess the specific influence of the policies discussed above on growth performance, this section presents multivariate growth regressions for a panel of OECD countries over the past two decades. In these regressions, policy variables are included, along with investment as explanatory variables of economic growth. To the extent that policy variables may also affect investment, there is a risk that their estimated coefficients pick up only part of their overall impact on growth.[17] For this reason, the growth equation is complemented with an investment equation. The growth equation is aimed at identifying the effect on output of a policy variable over and above its potential impact on investment, while the investment equation is intended to identify the impact of this policy variable on the level of investment.

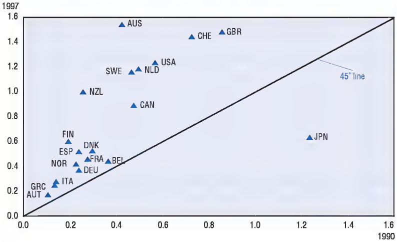
Figure 2.7. **Significant developments in financial systems**

Private credit of deposit money bank provided to the private sector
and stock market capitalisation as a percentage of the GDP, 1990 and 1997

Panel A. Private credit by deposit money banks to GDP



Panel B. Stock market capitalisation to GDP



Source: World Bank.

The estimated equation

The growth equation is derived from a growth model built around a constant returns-to-scale technology (see Annex 2 for more details). Output is a function of capital, employment, the efficiency with which they act together, and the level of technology. Given basic assumptions on how the factors of production evolve over time, the steady-state level of output per capita can be expressed as a function of the propensity to accumulate physical capital, the population growth rate, the level and growth rate of technological and economic efficiency, and the rate of depreciation of capital. Moreover, if the concept of capital is widened to include human capital, then the propensity to accumulate the latter is also a factor shaping the steady-state path of output per capita.

If countries were at their steady state – or if deviations from the steady state were random – growth equations could be simply based on the relationship linking steady-state output to its determinants. However, actual data may well include out-of-steady-state dynamics due, among other things, to a slow convergence to the steady state (see, amongst others, Mankiw *et al.*, 1992, for a discussion). Hence, the observed growth in output in any given period, abstracting from cyclical fluctuations, can be seen as the combination of three different forces: *i)* underlying technological progress – which is assumed to be exogenous; *ii)* a convergence process towards the country-specific steady-state path of output per capita; and *iii)* shifts in the steady state (growth or level of GDP per capita, see below) that can arise from changes in policy and institutions, as well as investment rates and changes in population growth rates.

The OECD sample permits the use of annual data instead of averages over time, as often done in the cross-country empirical literature.[18] However, year-to-year variations in output include cyclical components. These have been controlled for by including first differences of the steady-state determinants as short-run regressors in the estimated equations. Considering pooled cross-country time series (i denotes countries, t time) the growth equation, in its more general form, can be written as follows:

$$\Delta \ln y_{i,t} = a_{0,i} - \phi_i \ln y_{i,t-1} + a_{1,i} \ln sk_{i,t} + a_{2,i} \ln h_{i,t} - a_{3,i} n_{i,t} + \sum_{j=4}^{m} a_{j,i} \ln V^j_{i,t} + a_{m+1,i} t$$
$$+ b_{1,i} \Delta \ln sk_{i,t} + b_{2,i} \Delta \ln h_{i,t} + b_{3,i} \Delta n_{i,t} + \sum_{j=4}^{m} b_{j,i} \Delta \ln V^j_{i,t} + \varepsilon_{i,t} \quad [2.1]$$

where y is GDP per capita, s_K is the propensity to accumulate physical capital; *h* is human capital; *n* is population growth; V^j is a vector of variables affecting economic efficiency; t is a time trend; the *b*-regressors capture short-term dynamics and ε is the usual error term.

It should be stressed that equation [2.1] is a fairly general specification, and different growth models are nested in it. The estimated parameters of equation [2.1] allow distinguishing amongst some of these models. In particular, a significant coefficient on the lagged level of GDP per capita, i.e. the existence of convergence towards a country-specific steady state, would exclude one class of endogenous growth models (i.e. those *à la* Romer, 1986)[19]. However, this would not be sufficient evidence to rule out other endogenous models (e.g. *à la* Lucas, 1988).[20] Indeed, even in the presence of convergence, a number of empirical papers have interpreted the estimated policy coefficients as persistent *growth* effects.

The distinction between temporary or permanent growth effects may seem somewhat semantic if the speed of convergence to the steady state is very slow, as in most empirical studies focusing on a large set of countries.[21] However, consistent with some recent studies focusing on panel data, the evidence provided below suggests a relatively rapid speed of convergence for the OECD countries and thus, the choice between the two alternative interpretations of the results does matter in drawing policy conclusions. The approach used in this chapter is to consider the estimated coefficients as indicating temporary effects on growth due to the shift effect on the steady-state path of output per capita.

For reasons discussed in Box 2.2, the econometric procedure chosen for estimating equation [2.1] is the Pooled Mean Group (PMG) approach, which allows intercepts, the convergence parameter (ϕ), short-run coefficients (b_s) and error variances to differ freely across countries, but imposes homogeneity on long-run coefficients. A good argument can be made for common long-run coefficients for the OECD countries, given that they have access to common technologies and have intensive inter-linkages through trade and foreign direct investment, all factors contributing to lead to similar long-run production function parameters. With the PMG procedure, the following restricted version of equation [2.1] is estimated on pooled cross-country time-series data:

$$\begin{aligned}\Delta \ln y_{i,t} = &-\phi_i\left(\ln y_{i,t-1} - \theta_1 \ln sk_{i,t} - \theta_2 \ln h_{i,t} + \theta_3 n_{i,t} - \sum_{j=4}^{m}\theta_j \ln V_{i,t}^j + a_{m+1}t - \theta_0\right) \\ &+ b_{1,i}\Delta \ln sk_{i,t} + b_{2,i}\Delta \ln h_{i,t} + b_{3,i}\Delta n_{i,t} + \sum_{j=4}^{m} b_{j,i}\Delta \ln V_{i,t}^j + \varepsilon_{i,t}\end{aligned} \qquad [2.2]$$

where the long-run coefficients $a_{s,i}/\phi_i = \theta_s$ can now be read directly as the parameters of factors affecting the steady state path of output per capita.

Similarly, the investment equation has the general form:

$$\begin{aligned}\Delta \ln sk_{i,t} = & -\rho_i\left(\ln sk_{i,t-1} - \gamma_1 \ln y_{i,t} - \gamma_2 \ln h_{i,t} - \sum_{j=3}^{m}\gamma_j \ln V_{i,t}^{j} - \gamma_{0,t}\right) \\ & + c_{1,t}\Delta \ln y_{i,t} + c_{2,t}\Delta \ln h_{i,t} + \sum_{j=3}^{m} c_{j,t}\Delta \ln V_{i,t}^{j} + \varsigma_{i,t}\end{aligned} \qquad [2.3]$$

i.e. the share of business sector investment in GDP is assumed to depend on the level of GDP per capita, human capital and a set of policy and institutional factors.

Box 2.2. **The estimation technique**

Equation [2.1] can be estimated in different ways. At one extreme is a pure time-series approach, where all coefficients are treated as completely unrelated across countries. At the other extreme is the so-called dynamic-fixed-effects estimations, where the convergence parameter ϕ, and all a_s and b_s coefficients are assumed equal across countries.

Both methods have significant shortcomings. The first approach does not allow the exploitation of cross-country variability in the data to learn about the growth process, and is likely to be inefficient in small country samples, while the second imposes severe restrictions on the parameters, which are likely to be rejected by the data. In particular, the validity of the dynamic-fixed-effects approach depends critically on the assumption of a common technological progress and a common convergence parameter. While the first assumption is difficult to reconcile with evidence of multi-factor productivity patterns across countries (see Chapter 1), the latter is not consistent with the underlying growth model, where the speed of convergence depends, amongst other factors, upon the rate of population growth (see Annex 2).

This chapter uses a novel approach that lies in between these two cases : the Pooled Mean Group (PMG) procedure. Under the assumption of long-run slope homogeneity, the PMG estimator increases the efficiency of the estimates with respect to a pure time-series approach (Pesaran, *et al.*,1999). However, the hypothesis of homogeneity of the long-run policy parameters cannot be assumed *a priori* and, thus, it is tested empirically in all specifications.

Regression results and interpretation

The growth equations are estimated for 21 OECD countries over the period 1971-1998.[22] The countries are chosen because they have continuous annual series for most of the variables used in the growth equations over the bulk of the period. Details on the variables used in the regression are in Box 2.3. This section presents the core results of the econometric analysis. Supplementary estimates, details on the model selection process for the different specifications and sensitivity analysis can be found in Bassanini, *et al.* (2001).

Consistent with the standard neo-classical growth model, the initial specification only includes a convergence factor and the basic determinants of the steady state GDP per capita, namely the accumulation of physical capital and population growth. The first extension involves the introduction of human capital, while further extensions consider R&D and a set of policy and institutional factors potentially affecting economic efficiency.

The role of convergence and capital accumulation in the growth process

For various specifications (basic and extended) of the model, Table 2.3 reports the estimated coefficients and implied parameters for the basic factors driving the growth process, physical capital, human capital and convergence. All specifications suggest a process of (conditional) convergence, supporting the specification adopted in equation [2.2]. Moreover, in all specifications (whether basic or extended), both physical and human capital appear to have a positive and significant effect on economic growth. There is, however, some variability in the estimated magnitude of their impact that implicitly underlines the importance of model specification. In particular, standard growth equations that do not control for human capital may overestimate the effect of accumulation of physical capital on growth, while at the same time the model augmented with human capital yields an implausibly high coefficient on (*i.e.* return from) this factor.

More stable and reasonable coefficients are obtained in the three right-hand-side columns of Table 2.3, which report specifications that further augment the model with variables capturing framework conditions and policies. The estimated coefficients for physical capital are broadly consistent with other growth studies: *i.e.* on average a 1 percentage point increase in the investment share brings about an increase in steady-state GDP per capita of about 1.3 per cent.[23] The coefficients on human capital still suggest relatively high returns to education: the long-run effect on the level of GDP per capita of one additional year of education (corresponding to a rise in human capital by about 10 per cent) ranges between 4 and 7 per cent. These values contrast with many studies that found no or very limited effects of human capital on

Box 2.3. **Description of the variables used in the empirical analysis**

The baseline variables used in the regression include the following explanatory variables:

- *Dependent* variable (ΔlogY). Growth in real GDP per head of population aged 15-64 years expressed in (1993) Purchasing Power Parities (PPP);
- Catch-up variable ($\log Y_{-1}$). Lagged real GDP per head of population aged 15-64 years, in PPP;
- Physical capital accumulation (logSK). The propensity to accumulate physical capital is proxied by the ratio of real private non-residential fixed capital formation to real private GDP;[1]
- Stock of human capital (logH) is proxied by the average number of years of schooling of the population from 25 to 64 years of age.[2]
- Population growth (ΔlogP). Growth in population aged 15-64 years;

The auxiliary policy-related variables included in the augmented growth regressions were as follows:

- *Measures of inflation*: 1) the rate of growth of the private final consumption deflator (*Infl*); and 2) the standard deviation of the rate of growth in private final consumption deflator (*SDInfl*) – estimated over a three-year period (t_{-1}, t, t_{+1}).
- *Indicators of government size and financing*: 1) the ratio of general government current nominal tax and non-tax receipts in nominal GDP (*logTax*); 2) the ratio of direct to indirect tax receipts (*log(Tax distr)*; 3) the ratio of government nominal final consumption expenditure to nominal GDP (*log(Gov cons)*); and 4) the ratio of government real fixed capital formation to real GDP ($\log S_K^{gov}$).
- *Measures of R&D intensity*: 1) gross domestic expenditure on R&D as a percentage of GDP ($\log R\&D^{tot}$); 2) business sector expenditure on R&D as a percentage of GDP (*logBERD*); and 3) the percentage of BERD financed by industry ($\log BERD^{ind}$).
- *Indicators measuring financial development*: 1) private credit of deposit money banks provided to the private sector as a percentage of GDP (*logPCB*); and 2) stock market capitalisation as a percentage of GDP (*logSMC*).[3]

Box 2.3. **Description of the variables used in the empirical analysis** *(cont.)*

- *Indicators of the exposure of countries to foreign trade*: a weighted average of export intensity and import penetration.[4] In the empirical analysis this measure was adjusted for country size (*log(Trade exp)*^{adj}). It was achieved by regressing the crude trade exposure variable on population size and taking the estimated residuals from this exercise as the adjusted trade exposure.

All the auxiliary policy-related variables, with the exception of those related to R&D, have been introduced with a lag to better identify their impact on output. See Bassanini *et al.* (2001) for the discussion of this issue.

1. In the extended models, also government fixed capital formation is considered, but its impact on growth is allowed to differ from that of private fixed capital formation.
2. As discussed in Annex 2, growth regressions have often used enrolment rates from UN sources instead of education attainment, because the former are closer to the concept of investment in human capital. However, changes in enrolment rates are likely to have an impact of GDP per capita growth only with a long lag: in a model with annual data and with relatively limited time series (25-27 observations) there are inherent limits to the number of lags to be included in the specification. Moreover, a number of authors have questioned the use of enrolment rates as a proxy for the concept of human capital that influence decisions about fertility, participation and so on (see amongst others, Barro and Lee, 1996). There is also a practical issue that suggests using level data instead of first differences. Although the time series on human capital used in this study have been checked for consistency of definition over time (also on the basis of the work by de la Fuente and Doménech, 2000), they are often linear interpolations from five-year observations which make annual changes potentially misleading.
3. See Leahy *et al.* (2001) for more details on the pros and cons of these two indicators.
4. The index of trade exposure is calculated as follows: Trade Exp = $X_i + (1 - X_i)^*M_p$, where X_i is the ratio of exports to GDP and M_p is the ratio of imports to apparent consumption (domestic production minus exports plus imports).

growth (see for example, Benhabib and Spiegel, 1994; Barro and Sala-i-Martin, 1995). As pointed out by Bassanini and Scarpetta (2001), better data quality and a more appropriate econometric procedure are likely to account for the encouraging results on human capital reported in Table 2.3.[24] It should also be stressed that the present estimates are broadly consistent with estimated returns to schooling in the microeconomic literature (see Psacharopoulos, 1994).

The magnitude of the impact of human capital on growth found in this analysis might be interpreted as suggesting that the economy-wide returns to investment in education may be larger than those experienced by individuals. If this were the case, it could be through spillover effects such as links between education levels and advances in technology, through which human capital may not only affect the level of long-run output per capita, but may also have more persistent effects on growth. In the presence of such spillovers,

Table 2.3. **The role of convergence and accumulation of capital for growth: summary of regression results**

Pooled mean group estimates

Estimated coefficients	Standard equation[1]	Human-capital augmented	Trade-and-policy-augmented equations		
			A[2]	B[3]	C[4]
logSk	0.39***	0.18***	0.25***	0.23***	0.24***
	(0.11)	(0.04)	(0.04)	(0.04)	(0.04)
logH	...	1.00***	0.41***	0.70***	0.71***
		(0.10)	(0.13)	(0.16)	(0.13)
$\log Y_{-1}$	–0.05***	–0.12***	–0.17***	–0.15***	–0.15***
	(0 01)	(0.02)	(0.02)	(0.03)	(0.03)
half way to convergence[5]	13.9 years	5.3 years	3.9 years	4.3 years	4.3 years

Notes: All equations include a constant country-specific term and control for outliers. Standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1 % level.

1. The standard equation includes investment share in physical capital, population growth and lagged output per capita.
2. The equation also includes trade exposure, inflation and standard deviation of inflation.
3. The equation also includes trade exposure, standard deviation of inflation and tax and non-tax receipts.
4. The equation also includes trade exposure, standard deviation of inflation and government consumption.
5. Time to cover half way to convergence as implied by the estimated average coefficient of $\log Y_{-1}$.

Source: OECD.

incentives for individuals to engage in education may be usefully enhanced by policy to reap maximum benefits for society as a whole.[25]

However, there are some caveats to this interpretation of the results. First, the impacts found in the analysis may be over-estimated because the indicator of human capital may be acting partially as a proxy for other variables, an issue also raised in some microeconomic studies. In addition, the empirical analysis suggests that the impact is determined with some lack of precision. Finally, extending the period of formal education may not be the most efficient way of providing workplace skills, and this aspect of education must also be balanced against other (sometimes-competing) goals of education systems. Thus, for those countries at the forefront of education provision, the growth dividend from further increases in formal education may be less marked than that implied in the empirical analysis.

Overall, the estimated output elasticity to "broad" capital (*i.e.* physical and human) and the speed of convergence seem to be out of line with the predictions of the standard neo-classical growth model or with its human capital augmented version, and point to possible forms of endogenous growth (see Box 2.4).[26]

Box 2.4. **Consistency of results with different growth models**

In growth models that admit convergence, the growth rate of output is a function of the difference between actual and steady-state levels of output per capita, with a factor "λ" denoting the speed of adjustment. The latter can be derived from the estimated coefficient of the lagged logarithm of output per capita.[1]

As discussed in Annex 2, the parameters of the production function can be derived from the estimated long-run coefficients. The speed of convergence to the steady state can be expressed as a function of the rate of technological progress, the rate of growth of population, the depreciation rate of physical and human capital, as well as the estimated output elasticities to human and physical capital. The consistency of the empirical results with theoretical predictions can, therefore, be verified on this basis. The Table below reports elasticities of output and the average λ as derived from the estimated equations also summarised in Table 2.3 above. Furthermore, for each equation, the last line of the Table reports the "predicted" theoretical value of λ that would be compatible with the derived output elasticities, if the correct model were the standard neo-classical model (first equation), its human-capital-augmented version (second equation), and the trade and policy augmented version (last three equations).

The Table shows that the estimated output elasticity of capital is relatively stable across models and, although smaller than the capital share in national accounts statistics, it is in the range of the estimates found in the growth literature (between 0.1 and 0.4). Conversely, the estimated elasticity of output to human capital tends to be relatively high, especially in the specifications that do not control for trade and policy factors.

As usually found in other studies, the estimated speed of convergence λ is too low in the standard neo-classical specification (first column) with respect to what would be implied by the estimated value of the output elasticity to capital (theoretical λ). By contrast, in the augmented models, the estimated speed of convergence seems to be too high to be compatible with the different specifications of the growth model.[2]

1. Formally, the transition of output to its steady-state level can be expressed as $dy/dt = \lambda(y^* - y) + dy^*/dt$ where y denotes the logarithm of output per capita; y^* its the steady-state, and λ measures the speed of adjustment of output per capita to its steady-state. Denoting with ϕ the estimated coefficient for the (lagged) logarithm of output per capita, the estimated value of λ is equal to $-\log(1-\phi)$.
2. However, taken at face value, these results might be compatible with an endogenous growth model *à la* Lucas with constant returns to scale to "broad" capital (see Bassanini and Scarpetta, 2001 for more details).

Box 2.4. **Consistency of results with different growth models** *(cont.)*

Derived parameters from different specifications

Pooled mean group estimates

Estimated coefficients	Standard equation[1]	Human-capital augmented	Trade-and-policy-augmented equations		
			A[2]	B[3]	C[4]
Partial output elasticities					
Physical capital	0.28***	0.15***	0.20***	0.19***	0.20***
Human capital	...	0.85***	0.33***	0.57***	0.58***
Average λ[5]	0.05***	0.13***	0.18***	0.16***	0.16***
Theoretical λ[6]	0.09	0	0.08	0.03	0.03

Notes: All equations include a constant country-specific term and control for outliers. Standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1 % level.

1. The standard equation includes investment share in physical capital, population growth and lagged output per capita.
2. The equation also includes trade exposure, inflation and standard deviation of inflation.
3. The equation also includes trade exposure, standard deviation of inflation and tax and non-tax receipts.
4. The equation also includes trade exposure, standard deviation of inflation and government consumption.
5. Estimated average speed of convergence coefficient (derived from the estimated coefficient of $\log Y_{-1}$).
6. The value of λ that would be compatible with estimated output elasticities if, respectively, the standard and augmented neoclassical model were true. The value is computed by taking a depreciation rate of 10% (as estimated by Jorgenson and Stiroh, 2000), and assuming standard values for unknown parameters (2% as rate of technological change, 2% as rate of time preference, and 3 as elasticity of substitution in consumption, see Barro and Sala-i-Martin, 1995).

Source: OECD.

The role of policy and institutions for growth

In addition to the role of convergence and capital accumulation in the growth process, the empirical analysis provides evidence on the growth impact of variables reflecting macro policy, trade exposure and financial development (see Tables 2.4 and 2.5).[27]

Macro policy variables

Overall, the empirical analysis points to a significant impact of macro policy settings on output per capita across countries and over time. The variability of inflation appears to be an important negative influence on output per capita (Table 2.4), supporting the hypothesis that uncertainty about price developments affects growth via its impact on economic efficiency, for example by leading to a sub-optimal choice of potential investment projects,

Table 2.4. Macro-policy influences on growth[1]

Pooled mean group estimators

Dependent variable: ΔlogY	With control for inflation variables	With control for taxes and government expenditures		With control for both inflation and fiscal policy		
Long-run coefficients						
logSk	0.25***	0.36***	0.14***	0.29***	0.23***	0.24***
	(0.04)	*(0.04)*	*(0.04)*	*(0.05)*	*(0.04)*	*(0.04)*
logH	0.41***	1.26***	0.92***	0.88***	0.70***	0.71***
	(0.13)	*(0.22)*	*(0.13)*	*(0.19)*	*(0.16)*	*(0.13)*
ΔlogP	–5.69***	–3.86[2]	–15.70[2]***	–11.01***	–9.76***	–7.87***
	(1.02)	*(3.82)*	*(3.96)*	*(1.57)*	*(1.31)*	*(1.21)*
$SDinfl_{-1}$	–0.02***			–0.02***	–0.03***	–0.03***
	(0.00)			*(0.01)*	*(0.00)*	*(0.00)*
$Infl_{-1}$	–0.01***					
	(0.00)					
$logSk^{gov}_{-1}$		0.07***	0.09***	–0.02		
		(0.03)	*(0.02)*	*(0.02)*		
$log(Gov\ cons)_{-1}$		0.19***	–0.15**	0.04		–0.10**
		(0.04)	*(0.06)*	*(0.07)*		*(0.05)*
$logTax_{-1}$		–0.44***		–0.18**	–0.12**	
		(0.10)		*(0.07)*	*(0.05)*	
logTaxDistr		–0.08**				
		(0.04)				
$log(Trade\ exp^{adj})_{-1}$	0.20***	0.20***	0.10*	0.14**	0.20***	0.22***
	(0.05)	*(0.05)*	*(0.05)*	*(0.06)*	*(0.06)*	*(0.06)*
Convergence coefficient						
$logY_{-1}$	–0.17***	–0.17***	–0.21***	–0.13***	–0.15***	–0.15***
	(0.02)	*(0.04)*	*(0.05)*	*(0.03)*	*(0.03)*	*(0.03)*
No. of countries	21	17	21	17	18	21
No. of observations	523	427	522	427	444	523
Log likelihood	1 553	1 362	1 541	1 595	1 349	1 556

1. All equations include short-run dynamics and country-specific terms. Moreover, they control for outliers. Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.
2. The Hausman test rejected the hypothesis of common long-run coefficient and thus the coefficient was estimated without cross-country restrictions.

Source: OECD.

with lower average returns. Conversely, the effect of the level of inflation is less clear-cut: in the trade-augmented specifications presented in Table 2.4, the level of inflation seems to have a negative and significant impact on the steady state level of GDP per capita, but this is not so in some specifications (*e.g.* when the trade variable is excluded). The lack of robustness of the coefficient on the level of inflation may be related to the current low inflation observed in many OECD countries. Indeed, economic theory lends some support to the idea that the link between inflation and growth is likely to be

more uncertain at low levels of inflation (see *e.g.* Edey, 1994); Bruno and Easterly, 1998). On the one hand, it may be argued that further reductions in inflation, even towards zero inflation (or more stringently, price stability), would see continuation of the benefits of reduced inflation (see for instance Feldstein, 1996). On the other hand, negative effects on growth may emerge through nominal wage rigidities creating market inefficiencies (as suggested by Akerlof *et al.*, 1996).

The hypothesis that the size of government has an impact on growth receives some qualified support (Table 2.4).[28] The overall tax burden is estimated to have a negative impact on output per capita and, controlling for this factor, an additional negative effect is found for tax structures with a heavy weight on direct taxes. These results provide some support for the idea that the tax pressure – especially when focusing on so-called "distortionary" taxes affecting economic behaviour – could have an overall negative impact on output per capita, by influencing the efficiency of resource allocation across different investment projects. The composition of expenditure also appears to be important: with control for the financing of total government expenditure, both government consumption and investment seem to have a positive impact on output per capita. This could be taken to imply that the omitted type of expenditure in this analysis, *i.e.* public transfers, is driving the negative effects on total financing.[29]

Given the likelihood of interaction between monetary and fiscal indicators, it appears useful to check the robustness of the impact of macro policy variables by including both the variability of inflation and the different fiscal variables (last three columns of Table 2.4). The key result is the stability of the effects of both variability of inflation and government size (whether proxied by total tax burden or by government consumption in the last column of the Table).[30]

Indicators of financial market development

Some indication of the link between financial development and growth is presented in regressions, including indicators of private credit from the banking sector and stock market capitalisation. The results in Table 2.5 point to a robust link between stock market capitalisation and growth. The link between private credit provided to the private sector and growth has the wrong sign, but the banking credit indicator is not independent from other monetary variables, being strongly related to money supply and demand conditions. A more suitable model that also includes an inflation variable points to a positive relationship between private credit and growth. Overall, these results provide general support to the notion that the level of financial development influences growth, over and above its potential effect on investment (*i.e.* even after controlling for the propensity to invest). This

Table 2.5. **The influence of financial market developments on growth**[1]

Pooled mean group estimators

Dependent variable: ΔlogY	With private credit	… And control for inflation	With stock market capitalisation
Long-run coefficients			
logSk	0.07	0.30***	0.14***
	(0.06)	*(0.06)*	*(0.02)*
logH	1.04***	0.99***	0.93***
	(0.12)	*(0.14)*	*(0.15)*
ΔlogP	–14.48***	–11.54***	–4.80***
	(2.34)	*(1.77)*	*(0.89)*
log(Priv credit)$_{-1}$	–0.14***	0.04**	
	(0.04)	*(0.02)*	
log(Stock cap)$_{-1}$			0.09***
			(0.01)
SDInfl$_{-1}$		–0.02***	
		(0.00)	
Convergence coefficient			
logY$_{-1}$	–0.10***	–0.13***	–0.22***
	(0.02)	*(0.02)*	*(0.05)*
No. of countries	21	21	18
No. of observations	523	523	338
Log likelihood	1449	1498	1058

1. All equations include short-run dynamics and country-specific terms, and control for outliers. Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.
Source: OECD.

perhaps points to a greater capacity of more developed financial systems to channel resources towards projects with higher returns.

Research and development

The analysis of the determinants of growth can be further extended to include R&D activities, even though the sample is smaller and the inference, thus, more tentative.[31] The indicators of R&D activity used here are expenditures on R&D as collected in national accounts and expressed as a percentage of GDP. They are, thus, indicators of the "intensity" of R&D within each country. The results (Table 2.6) support previous evidence, suggesting a significant effect of R&D activity on the growth process.[32] Furthermore, regressions including separate variables for business-performed R&D and that performed by other institutions (mainly public research institutes) suggest that it is the former that drives the positive association between total R&D intensity and output growth.[33] There are also possible interactions between

Table 2.6. **Growth regressions including R&D intensity variables**[1]

Pooled mean group estimators

Dependent variable: ΔlogY	With total R&D	With distinction between business and non-business R&D	With business R&D only
Long-run coefficients			
logSk	0.31***	0.28***	0.34***
	(0.03)	(0.02)	(0.02)
logH	1.13***	1.76***	0.82***
	(0.16)	(0.05)	(0.18)
ΔlogP	–12.15***	–33.19[2]**	–16.43***
	(1.64)	(13.94)	(2.02)
$logR\&D^{tot}$	0.14***		
	(0.03)		
logBERD		0.26***	0.13***
		(0.01)	(0.02)
$logR\&D^{pub}$		–0.37***	
		(0.04)	
$log(Trade\ exp^{adj})_{-1}$	0.33***		0.32***
	(0.05)		(0.05)
Convergence coefficient			
$logY_{-1}$	–0.22***	–0.23**	–0.18***
	(0.05)	(0.11)	(0.04)
No. of countries	16	15	16
No. of observations	252	236	251
Log likelihood	860	831	849

1. All equations include short-run dynamics and country-specific terms. Moreover, they control for outliers.
Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.
2. The Hausman test rejected the hypothesis of common long-run coefficient and thus the coefficient was estimated without cross-country restrictions

Source: OECD.

R&D and international trade that are not explored in the analysis: for example, domestic R&D may have a smaller impact on growth in countries widely exposed to foreign R&D through trade.[34]

The negative results for public R&D are surprising and deserve some qualification. Taken at face value they suggest publicly-performed R&D crowds out resources that could be alternatively used by the private sector, including private R&D. There is some evidence of this effect in studies that have looked in detail at the role of different forms of R&D and the interaction between them.[35] However, there are avenues for more complex effects that regression analysis cannot identify. For example, while business-performed R&D is likely to be more directly targeted towards innovation and implementation of new innovative processes in production (leading to

improvement in productivity), other forms of R&D (*e.g.* energy, health and university research) may not raise technology levels significantly in the short run, but they may generate basic knowledge with possible "technology spillovers". The latter are difficult to identify, not least because of the long lags involved and the possible interactions with human capital and associated institutions.[36]

Policy and institutional influences on capital accumulation

The previous section has focused on the direct influence of policy variables on growth, over and above their potential effects on the accumulation of physical capital. Therefore, in order to assess their overall impact on growth, it seems useful to explore whether they also affect growth indirectly, *via* an effect on investment. For this purpose, investment-share regressions are estimated (Table 2.7), using the general specification

Table 2.7. **Investment regressions**[1]

Pooled mean group estimators

Dependent variable: ΔlogSk				
Long-run coefficients				
$SDinfl_{-1}$	–0.02*	–0.01*		
	(0.01)	*(0.01)*		
$Infl_{-1}$	–0.02***	–0.03***	–0.02***	–0.03***
	(0.01)	*(0.00)*	*(0.00)*	*(0.01)*
$logSk^{gov}{}_{-1}$	–0.21***	–0.11**	0.02	–0.05
	(0.06)	*(0.04)*	*(0.03)*	*(0.03)*
$log(Gov\ cons)_{-1}$	–0.26*		–0.71***	
	(0.15)		*(0.14)*	
$logTax_{-1}$		–0.77***		–0.36**
		(0.12)		*(0.14)*
$log(Stock\ cap)_{-1}$			0.14***	0.17***
			(0.01)	*(0.02)*
$log(Priv\ credit)_{-1}$	0.09**	0.06		
	(0.03)	*(0.04)*		
$log(Trade\ exp^{adj})_{-1}$	–0.32***	–0.05	0.05	–0.31***
	(0.12)	*(0.08)*	*(0.10)*	*(0.09)*
Convergence coefficient				
$logSk_{-1}$	–0.15***	–0.22***	–0.27***	–0.26***
	(0.03)	*(0.05)*	*(0.07)*	*(0.05)*
No. of countries	21	18	18	16
No. of observations	531	443	338	301
Log likelihood	936	776	693	601

1. All equations include short-run dynamics and country-specific terms, and control for outliers. Standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level.
Source: OECD.

presented in equation [2.3] above.[37] Overall, judging from these results and those of the previous section, three main policy and institutional variables seem to influence growth, both directly and indirectly: inflation, the "size" of the government and financial development.

In contrast with the results from the growth equation, the negative effect of the level of inflation is more significant than that of its variability in investment regressions. This finding is consistent with the view that uncertainty about inflation, as captured by its variability, mainly influences growth *via* distortion in the allocation of resources (as discussed above), rather than by discouraging the accumulation of physical capital, while high levels of inflation indeed discourage savings and investment. There is also evidence that the "size" of government may be negatively associated with the rate of accumulation of private capital, as can be seen by looking at the coefficients of the two proxies (taxes or government consumption in the specification without taxes).

Finally, financial development might positively affect investment. As in the growth regressions, the indicator of credit provided by the banking sector appears to be only weakly associated with investment, while the stock market capitalisation has a stronger effect.[38] These results are consistent with a number of empirical studies attempting to explain cross-country differences in growth across a broad range of countries (including OECD and non-OECD economies), which have concluded that financial development plays a significant role (see, for example, Levine, 1997; Levine *et al.*, 2000; Temple, 1999).

2.3. Assessing the long-run effects of policy and institutional changes on GDP per capita

The results of the previous section can be used to assess the effect of a given change in a policy or institutional variable on steady-state output per capita. Two important caveats need to be borne in mind in this exercise. First, as discussed above, it has been assumed that the policy and institutional variables affect only the *level* of economic efficiency and not its steady-state growth rate: the magnitude of the growth effects of some policy changes may, therefore, be underestimated. Second, the calculations should only be taken as broad indications, given the variability of coefficients across the specifications and interaction effects between variables that may be important but cannot be taken into account.

Bearing in mind the illustrative nature of this exercise, the estimated *direct effects* – derived from the growth equations that control for the level of investment and *indirect effects* – derived by combining the effect on investment

with that of the latter on output per capita – of policy variables are as follows (see also Table 2.8):

- The point estimate for the variability of inflation suggests that a reduction of 1 percentage point in the standard deviation in inflation – *e.g.* about one-half of the reduction recorded on average in the OECD countries from the 1980s to the 1990s – could lead to a 2 per cent increase in long-run output per capita, *ceteris paribus*.
- The effect of the level of inflation works mainly through investment: a reduction of one percentage point – *e.g.* one-quarter of that recorded in the OECD between 1980s and 1990s – could lead to an increase in output per capita of about 0.13 per cent, over and above what could emerge from any accompanying reduction in the variability of inflation.
- Taxes and government expenditures seem to affect growth both directly and indirectly through investment. An increase of about one percentage point in the tax pressure – *e.g.* slightly less than what was observed over the past two decades in the OECD sample – could be associated with a direct reduction of about 0.3 per cent in output per capita. If the investment effect is taken into account, the overall reduction would be about 0.6-0.7 per cent.

Table 2.8. **Estimated impact of changes in institutional or policy factors on output per capita**[1]

Variable	Impact on output per working age person (per cent)[2]			Order of magnitude with respect to OECD experience (1980s-90s)[3]
	Effect via economic efficiency	Effect via investment	Overall effect	
Inflation rate (Fall of 1% point)		0.4 to 0.5	0.4 to 0.5	About 1/4 the observed fall
Variability of inflation (1% point fall in SD of inflation)	2.0		2.0	About 1.5 times the observed fall
Tax burden[4] (Increase of 1% point)	–0.3	–0.3 to –0.4	–0.6 to –0.7	About ⅔ of the observed increase
Business R&D intensity[4] (Increase of 0.1% points)	1.2		1.2	About the increase observed
Trade exposure[4] (Increase of 10% points)	4.0		4.0	About the increase observed

1. The values reported in this table are the estimated long-run effects on output per working-age person of a given policy change.
The range reported reflects the values obtained in different specifications of the growth equation.
2. The direct effect refers to the impact on output per capita over and above any potential influence on the accumulation of physical capital.
The indirect effect refers to the combined impact of the variable on the investment rate and by that channel, on output per capita.
3. Average change from the 1980 average to the 1990 average in the sample of 21 OECD countries, excluding new members as well as Iceland, Luxembourg and Turkey.
4. In percentage of GDP.

Source: OECD.

- A persistent 0.1 percentage point increase in R&D intensity (about 10 per cent increase with respect to average R&D intensity) would have a long-run effect of about 1.2 per cent higher output per capita under the "conservative" interpretation of the estimation results. However, in the case of R&D it is perhaps more appropriate to consider the results as reflecting a permanent effect on growth of GDP per capita (*i.e.* a fall in R&D intensity is unlikely to reduce the steady-state level of GDP per capita but rather reduces technical progress). If the R&D coefficient is taken to represent growth effects, a 0.1 percentage point increase in R&D could boost output per capita growth by some 0.2 per cent. These estimated effects are large, perhaps unreasonably so, but nevertheless point to significant externalities in R&D activities.
- Finally, an increase in trade exposure of 10 percentage point – about the change observed over the past two decades in the OECD sample – could lead to an increase in steady-state output per capita of 4 per cent.

2.4. Concluding remarks

This chapter has investigated empirically the growth contribution of different forms of investment (physical, human, knowledge) and various policy and institutional settings across OECD countries and over time. In broad terms, the estimated growth regressions explain much of the observed growth paths across countries and over time. Notably, the results point to a high speed of convergence to the steady-state growth path, compared with previous estimates based on a larger set of countries and cross-section data. This implies that observed cross-country differences in GDP per capita levels may be largely the result of differences in long-run equilibrium levels rather than different positions of countries along a similar growth path. Thus, changes in the determinants of the equilibrium – including the accumulation of physical and human capital, R&D trade exposure, financial structures and macroeconomic conditions – can be translated relatively rapidly into changes in living standards.

- More specifically, the analysis confirms the importance of investment in physical and human capital. In the latter case the results also point to potential externalities in investment in education, *i.e.* social returns seem higher than private returns, at least in some countries and periods where education levels were relatively low. However, these externalities may arise mainly in the case of compulsory education, insofar as other OECD work indicates that private returns may exceed social returns for post-compulsory education.
- There is also confirmation that sound macro policy settings are conducive to higher growth paths. In particular, the reduction in the levels of inflation in most OECD countries could have stimulated the accumulation of physical

capital in the private sector and, through this channel, had a positive bearing on output. Moreover, the reduction in the variability of inflation may have contributed to a shift in the composition of investment towards more risky but also higher return projects.

- In addition, the empirical evidence lends some support to the notion that the overall size of government in the economy may reach levels that hinder growth. Although expenditure on health, education and research clearly sustains living standards in the long term, and social transfers help to meet social goals, all have to be financed. The results suggest that for a given level of taxation, higher direct taxes lead to lower output per capita, while, on the expenditure side, government consumption and government investment tend to have positive effects on output per capita. Government investment may also influence growth by improving the framework conditions (*e.g.* better infrastructure) in which private agents operate.
- Research and development activities undertaken by the business sector seem to have high social returns, while no clear-cut relationship could be established between R&D activities not undertaken by businesses and growth. There are, however, possible interactions and international spillovers that the regression analysis cannot identify. Moreover, certain public R&D (*e.g.* energy, health and university research) may in the long run generate basic knowledge, with possible "technology spillovers".
- Finally, the empirical evidence also confirms the importance of financial markets for growth, both by helping to channel resources towards the most rewarding activities, and in encouraging investment.

Although the factors identified in this chapter appear to be crucial to understanding growth patterns across countries and over time, there are a number of additional determinants that could not be directly analysed. In particular, in the current period, characterised by a process of adaptation to information and communication technologies, a number of other policy and institutional factors are also likely to play a key role, by influencing the ability of markets to adapt to the new technologies. The latter requires reallocating resources to new activities, re-shaping existing firms and discovering new business opportunities. The subsequent chapters will look at these institutional and policy factors exploring their impact on industry and individual firms' performance.

Notes

1. This chapter draws heavily from Bassanini, Hemmings and Scarpetta (2001).
2. This extreme view may not hold, even in neo-classical models, if one assumes that policy, by influencing the allocation of resources across individuals, may affect saving behaviour.

3. For example, new-growth models that incorporate a knowledge-producing sector can be interpreted as incorporating the role that research universities may play in growth. An early example of this type of model was by Uzawa (1965), later examples by Lucas (1988), Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1998).
4. OECD (2000a) provides more details on recent trends in R&D intensity. In particular, the decline in government spending in R&D has been affected by the reduction in the military R&D budget in the aftermath of the end of the cold war. Moreover, government spending declined in the early 1990s as a result of the efforts to reduce fiscal imbalances.
5. See Temple (1998) for a comprehensive discussion of theories linking inflation with growth.
6. For instance, the tax structure usually includes nominally-denominated allowances, so that as inflation rises, tax allowances (credits) decline and the effective cost of investment rises (Jones and Manuelli, 1993). Moreover, if money is required to buy capital goods, the effective cost of capital increases with the inflation rate (Stockman, 1981 ; De Gregorio, 1993).
7. Mundell (1963) ; Tobin (1965).
8. See Ball and Cecchetti (1990) for a review.
9. Barro (1976, 1980). Several studies show that the variability of prices across goods and the variability of prices of the same goods across stores increases with inflation (see Lach and Tsiddon, 1992, for a survey).
10. See Bernanke (1983) Pindyck (1991), and Ramey and Ramey (1995). However, not all links between output volatility and growth may be negative. For instance, some have argued that there may be a choice between high-variance, high-expected-returns technologies and low-variance, low-expected-returns technologies (*e.g.* Black, 1987). Lower output volatility would tend to be associated with lower output growth. Moreover, one should keep in mind that cross-country differences in the volatility of output may, to some extent, reflect differences in the "size" of economies. Greater diversity of activities in larger economies implies that sector-specific shocks carry less weight in aggregate outcomes. In addition, "large" economies are typically less exposed to external shocks as trade balances are relatively small compared with smaller economies.
11. These two countries have experienced very large and opposite changes in their variability of inflation from the 1980s to the 1990s, while at the same time improving their growth performance.
12. For example, long-run data often show that government expenditure as a share of GDP tends to rise with living standards (Wagner's law), reflecting income-elastic demand for key government services (health, education and law and order). Kolluri *et al.* (2000) find strong support for Wagner's law operating in OECD countries, based on regressions linking total government expenditure with GDP.
13. See amongst others, Barro (1990); Barro and Sala-i-Martin (1995); Mendoza *et al.* (1997).
14. Unlike non-distortionary taxes, distortionary taxes affect the economic choices of households and firms, notably with respect to the level and composition of their (human and physical) capital investment. By contrast, non-distortionary taxes are more neutral. Non-distortionary taxes mainly relate to taxation on domestic goods and services, while distortionary taxes include taxation on income and profits, taxation on payroll and manpower. Some simulations made by Jorgenson

and Yun (1986, 1990) show that a shift from direct to indirect taxation could lead to significant output gains in the United States.

15. Transfer programmes are often taken as examples of the second group (see *e.g.* Hubbard *et al.*, 1995; Leonard and Audenrode, 1993). However, redistributional transfers may buy poor people out of disruptive activities, with potentially positive effect on output growth (Sala-i-Martin, 1997; Phelps, 2000).

16. One limitation of the stock market capitalisation indicator is that it does not capture the development of the banking system, the role of debt securities, or other parts of the equity market (not-listed equity). Moreover, it measures the market value of existing listed companies rather than the amount of funds raised in the equity market in any particular year.

17. For example, if a variable has a positive bearing on output independently of its positive impact on investment, its estimated coefficient in a growth regression that includes, on the right-hand side, the investment rate, will under-represent its total impact on output. Alternatively, if the policy variable has a positive independent effect on output growth but a negative effect on investment, the estimated coefficient in the growth regression will exaggerate the effect of the policy variable on growth.

18. Where data for a large number of countries was available, growth regressions have typically taken averages over long time periods (*e.g.* 20 years). Other studies have taken averages over 5-year periods (see *e.g.* Islam, 1995; Caselli *et al.*, 1996). The use of time averages raises two possible problems: it implies a potential loss of information; and, more importantly, in cases of un-synchronised business cycles., it does not purge the data from country-specific cyclical influences.

19. This concerns, for example, one-sector models of endogenous growth in which capital is not characterised by diminishing returns (see *e.g.* Romer, 1986; Rebelo, 1991).

20. This concerns models of endogenous growth, which explicitly consider different types of capital goods (*e.g.* physical and human), each characterised by its own accumulation process (*e.g.* investment and education). See Uzawa (1965); Lucas (1988); Barro and Sala-i-Martin (1995).

21. Estimates of the speed of convergence to steady-state output vary in the literature: while most studies estimated values around 2-3 per cent per year (Mankiw, *et al.*, 1992; Barro and Sala-i-Martin, 1995) – which implies that an economy spends about 20-30 years to cover half of the distance between its initial conditions and its steady state – a few have found values of 10 per cent or more for the OECD countries (e.g. Caselli *et al.*, 1996), which imply less than 9 years to cover half of the distance.

22. The country sample include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany (western), Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.

23. This is obtained from the long-run coefficient (the partial long-run elasticity) and the implied variation from a one percentage point change in the cross-country average investment share.

24. Using a similar proxy, de la Fuente and Doménech (2000) also found a strongly significant coefficient for human capital in level and growth equations, which confirms the important role of data quality.

25. However, these results may also be driven by distortions (*e.g.* excessive taxation or wage compression) that discourage investment in human capital by individuals.

26. It should be stressed that these conclusions do not depend on a particular specification of the growth regression. They are indeed confirmed by a sensitivity analysis presented in Bassanini and Scarpetta (2001).

27. Each policy-augmented specification was estimated with and without the trade exposure variable to test for the sensitivity of coefficients. As discussed in Bassanini and Scarpetta (2001), the coefficient on trade exposure is always significant and the equations reported here include this variable. These results are consistent with, amongst others, Miller and Russek (1997) who focused on OECD countries in their empirical analyses.

28. The overall measure of tax and non-tax revenue can be used only for a sub-sample of 18 OECD countries, due to data availability.

29. The coefficient on government consumption becomes negative once the financing variables are excluded because, in this case, government consumption acts as a proxy for the "size" of government intervention.

30. By contrast, government investment becomes insignificant as soon as the model is extended and is dropped in the final specification on the right-hand side of the Table.

31. In particular, the analysis is restricted to 14-17 countries (depending on the specification) and the period 1981-98 (and for some countries the period is shorter). The shorter time-series significantly restrict the number of variables that could be considered in the regressions. These include, in addition to the R&D variables, the basic controls and trade exposure, whenever possible. It should be stressed that the coefficients on both physical and human capital maintain the sign and statistical significance they had in the regressions estimated over the larger sample, although convergence is faster. This latter result is not driven by the small country sample but rather by the shorter time period over which the model is estimated (see Bassanini and Scarpetta, 2001)

32. See Fagerberg (1994); and Englander and Gurney (1994).

33. Park (1995) also found private-sector R&D to be more important than public R&D in OECD-based growth regressions.

34. These possible interactions between R&D and international trade have been emphasised by several other studies. For instance, Coe and Helpman (1995) find significant interaction between import propensities and the ability to benefit from foreign R&D: *i.e.* for a given level of R&D performed abroad, countries with higher import propensity have higher productivity growth. Moreover, small countries benefit more from R&D performed abroad than from domestic R&D. Sachs and Warner (1995) claim trade openness as being an important constraint to convergence for many developing countries. At the same time, Ben-David and Kimhi (2000), using aggregate data on trade between (mainly) OECD countries, find evidence to support the idea that increasing trade between pairs of countries is associated with an increased rate of convergence.

35. Lichtenberg (1988) finds that non-competitive R&D procurement tends to crowd out private R&D investment, while competitive procurement stimulates it. See David *et al.* (1999) for a survey. By contrast, Guellec and Van Pottelsberghe (1997, 2001) support the complementarity hypothesis.

36. Given the short time period that can be used in this sample, lagging the R&D variable would have induced an excessive loss of degrees of freedom.

37. Following experimentation with three control variables, lagged output per capita, human capital and lagged trade exposure, the preferred specification includes only a control for trade exposure (see Bassanini and Scarpetta, 2001).

38. However, data limitations constrained the number of variables that could be included alongside the indicator of stock market capitalisation. Moreover, the interpretation of the causality link between stock market capitalisation and investment may be problematic: the former is driven by changes in valuation of listed companies which in turn could be driven by factors also influencing investment.

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Chapter 3

What Drives Productivity Growth at the Industry Level?

Abstract. *This chapter[1] extends the analysis of how policy influences growth by exploring industry-level data. In particular, it assesses how different policy and institutional settings in both product and labour markets affect productivity and innovation activity. Aggregate productivity patterns are largely the result of within-industry performance in the OECD countries, and the latter is negatively affected by strict product market regulations, especially if there is a significant technology gap with the technology leader. There is also evidence of an indirect negative effect of strict product market regulations on productivity via their impact on innovation activity. Likewise, by raising labour adjustment costs, strict employment protection legislation tends to hinder productivity, unless these higher costs are offset by lower wages and/or more internal training. However, strict employment protection legislation does not affect innovation activity, but rather tends to tilt sectoral specialisation towards industries where technological enhancement can be accommodated with internal training.*

Introduction

Assessing the role of policy and institutions for long-term growth cannot be limited to aggregate analysis. It also requires exploration of the role played by within-industry performance and reallocation of resources across industries and firms. Indeed, the macro analysis may fail to capture the effects of specific policies – such as product market regulations and trade restrictions – on industry performance. Likewise, differences in growth patterns at the industry level may also point to variations in the extent to which countries are benefiting from broader economic changes, or from the potential offered by new technologies. For example, as discussed in Chapter 1, technological change has enabled rapid productivity growth in the ICT-producing industry and, most recently, in ICT-using industries, but there are considerable variations in the degree to which countries have benefited from such potential. The remainder of the book is devoted to the exploration of these aspects of growth, by using industry and firm-level data.

The purpose of this chapter is twofold. It first reviews the role played by within-industry growth and reallocation across industries in the growth process (Section 3.1). It finds that most of the observed aggregate productivity growth is due to within-industry performance, with only a minor role played by the reallocation of resources from less to more productive industries. However, there is also evidence that certain industries – mostly related to ICT – have made a particularly strong contribution to overall productivity growth in some countries. This finding, in turn, raises the more general question as to why some countries have more than others enjoyed productivity gains associated with innovation and adoption of new technologies. The chapter addresses this question analytically, by assessing the role of policy and institutional settings – in particular product and labour market regulations – in driving productivity growth (Section 3.2). This complements the analysis presented in Chapter 2 that focused on the role of aggregate framework conditions for productivity and growth.

3.1. Within-industry growth and reallocation of resources across industries

The analysis of sectoral performance and its contribution to aggregate growth patterns is organised as follows. The contribution of structural shifts across broad sectors of the economy to overall productivity patterns is first

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assessed. Since most of aggregate productivity growth seems to be due to *within* industry patterns, the section then focuses on the sources of productivity growth at the sectoral level.

Structural changes and labour productivity growth

Historically, structural shifts were an important factor behind productivity growth as resources moved from a low-productive agricultural sector to a more productive manufacturing sector. More recently, however, evidence from aggregate data seems to suggest that a large contribution to overall productivity growth patterns comes from productivity changes within industries, rather than as a result of significant shifts of employment across industries (Van Ark, 1996). For the purpose of international comparison, Figure 3.1 presents a decomposition of labour productivity growth in the business sector into three elements:[2]

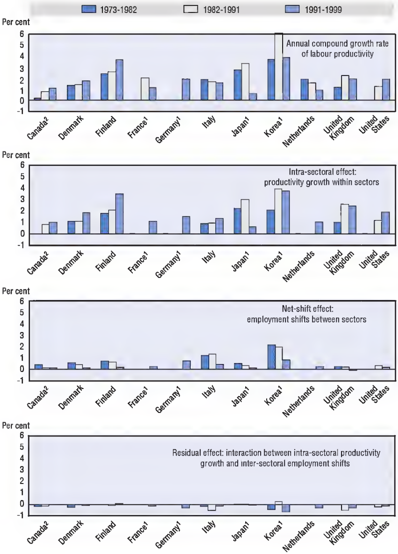
- An "intra-sectoral effect", measuring productivity growth within industries.
- A "net-shift effect", measuring the impact on productivity of the shift in employment between industries.
- And a residual third effect, the "interaction effect". This effect is positive when sectors with rapid productivity growth also increase their industry employment share, or when industries with falling relative productivity decline in size. It is negative when industries with growing relative productivity decline in size or when industries with falling productivity grow in size.

Bearing in mind the limits of a decomposition based on rather broad industries, the results of these calculations show that the intra-industry effect is the most important contributor to productivity growth in the non-farm business sector (Figure 3.1). In a few countries the net-shift effect also makes an important contribution, due notably to the increased size of the business services sector, but its impact seems to fade out during the 1990s. The interaction effect tends to be negative for most countries.[3] These results are in line with those obtained when looking at manufacturing only (Figure 3.1): employment shifts across manufacturing industries played a very modest role in most countries.

The evidence that productivity growth is more than ever a matter of performance improvement within industries is perhaps not surprising for the countries examined in Figure 3.1, as around 70 per cent of value-added in these countries is already in services. However, other OECD economies, including Ireland and Japan, as well as some low-income countries, have a much smaller business service sector, suggesting that there may be further scope for structural change. In addition, there is likely to be scope for further

Figure 3.1. **Decomposition of aggregate labour productivity growth into intra-sectoral productivity growth and inter-sectoral employment shifts**

Non-farm business sector



1. 1991-1998 instead of 1991-1999.
2. 1991-1996 instead of 1991-1999.

Source: OECD.

structural change and improved resource allocation within the industries considered in Figure 3.1.[4]

The breakdown of labour productivity growth by sector

Labour productivity growth has differed significantly across industries within each country, with particular industries showing strong performances. Indeed, over the 1990s, the manufacturing sector contributed around half of overall productivity growth in several countries, including most major economies, although it accounts for only about 20 per cent of total employment. More interestingly, however, the contribution to productivity growth of specific industries varies across the major OECD economies (Figure 3.2). In the United States, manufacturing and service industries that are most closely related to ICT, either in terms of ICT production or ICT use (*e.g. machinery and equipment* in manufacturing and *trade* and *financial activities* in the service sector) have made a strong contribution to the acceleration in labour productivity growth from the first to the second half of the 1990s. Europe (and Japan) did not receive such a contribution from ICT related industries, and their aggregate labour productivity growth remained fairly stable or even declined.

All in all, the evidence provided in this section points to the need to analyse the determinants of productivity growth at the detailed industry level. Indeed, the fact that the reallocation of resources across industries has played a minor role in explaining aggregate differences in productivity growth implies that the results emerging from the industry-level analysis may be generalised to reflect aggregate patterns. The next section sketches the main theoretical links between policy and institutional settings and industry productivity, while the following section presents empirical evidence on such links.

3.2. An overview of the potential influences of policies and institutions on productivity

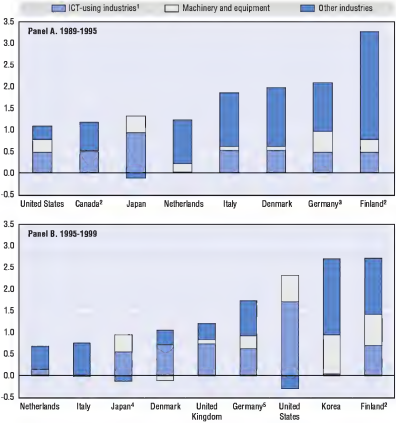
This section presents three factors, all directly or indirectly influenced by policies and institutions, that may affect industry-level productivity: *i)* the degree of competition in the product market; *ii)* institutional settings in the labour market; and *iii)* innovation activities performed by the business sector, which are at least partially influenced by policy intervention, either directly by publicly-financed R&D, or indirectly by tax rebates on R&D expenditure.

Product market competition, regulations and productivity

Different arguments can be advanced to suggest that, for a given level of protection of intellectual property rights, greater competition is likely to lead

Figure 3.2. **The contribution of ICT-related industries to labour productivity growth**

Percentage changes in value added per person employed, 1989-1995 and 1995-1999



1. Wholesale and retail trade, repairs; finance, insurance, real estate and business services.
2. Value added per hour worked.
3. 1991-1995.
4. 1995-1998.
5. 1995-1997.

Source: OECD.

to stronger productivity performance (see Box 3.1).[5] In weakly competitive markets, there are relatively few opportunities for comparing firms' performances, and firm survival is not immediately threatened by inefficient practices. Therefore, slack and the sub-optimal use of factor inputs can persist. As competitive pressures increase, performance comparisons become easier and the risk of losing market shares encourages the elimination of

Box 3.1. **The theoretical links between product market competition and productivity**

Textbook theory suggests that competition in the product market brings about allocative efficiency gains by forcing prices to converge to marginal costs. In addition to such static gains, a variety of theoretical analyses based on information asymmetry between managers and owners have indicated potential gains from "dynamic efficiency". These dynamic gains are likely to emerge because firms will continue to improve their performance in ways they would not if competitive pressures were weak (Winston, 1993).

Theoretical models focusing on dynamic efficiency generally originate from the idea that monopoly rents are often captured by managers (and possibly workers) in the form of managerial "slack" or reduced work effort. In this context, at least three different channels can be identified, through which product market competition would discipline firms into efficient operation (Nickell *et al.*, 1997). First, competition creates greater opportunities for comparing performance, making it easier for the owners or the market to monitor managers (Lazear and Rosen, 1981; Nalebuff and Stiglitz, 1983). Second, cost-reducing improvements in productivity could generate higher revenue and profit in a more competitive environment, where price elasticity of demand tends to be higher. Third, since more competition is likely to raise the likelihood of bankruptcy, managers may work harder to avoid this outcome (Aghion and Howitt, 1998). In addition, if product market rents are partly shared with workers in the form of higher wages or reduced effort, then competition probably influences workers' behaviour too (Haskel and Sanchis, 1995).

It should be stressed that theoretical predictions of the effects of greater competition on incentives are often "subtle and ambiguous" (Vickers, 1995). For example, though models using *explicit* incentives under information asymmetry do not lead to clear-cut implications (see *e.g.* Holmström, 1982), intertemporal models using *implicit* (*i.e.* market-based) rewards suggest a positive link between competition and managerial effort if productivity shocks are more correlated across competitors than managerial abilities (Meyer and Vickers, 1997). But competition could, on the contrary, lead to more slack if managers are highly responsive to monetary incentives (Scharfstein, 1988). Similarly, while higher demand elasticity under competition increases the relative rewards from cost reduction, larger scale operations for a monopolist

Box 3.1. **The theoretical links between product market competition and productivity** *(cont.)*

tend to increase the absolute reward from a similar cost reduction. All in all, depending on the setting of the model, competition is shown to improve efficiency in many, but not all, circumstances.

The effect of competition on productivity through innovative activity has also been extensively analysed. In the basic Schumpeterian approach, innovation and growth decline with competition because the monopoly rents from innovations tend to be dissipated more quickly when there is greater competition, thereby lowering the expected returns from innovations. However, the empirical evidence tends to show an opposite, *i.e.* positive, relationship. In order to reconcile theory with this empirical evidence, Aghion and Howitt (1998) have extended the basic Schumpeterian model to offer several cases where competition can be conducive to greater innovation. First, in a rapidly changing technological environment, there might be a *Darwinian effect*, whereby intensified competition forces managers to speed up the adoption of new technologies in order to avoid bankruptcy. Even if technological progress is more gradual, *i.e.* when firms are engaged in step-by-step innovative activities, greater competition may induce *"neck-and-neck"* firms to invest more in R&D in order to acquire a lead over their rivals (see also Aghion *et al.*, 2001). Finally, insofar as increased competition increases the mobility of skilled workers to newer lines, it may stimulate overall growth in the presence of learning by doing (*mobility effect*).

slack. In parallel, the need to meet the cost efficiency of competing firms provides a powerful motivation for adjusting technology and work organisation to best practice.

However, the empirical evidence supporting these arguments is still fairly limited,[6] partly due to the difficulty of measuring competitive pressures. Traditional indicators of product market conditions used in most studies, such as mark-ups, industry concentration indexes[7] or market shares,[8] cannot be treated as exogenous determinants of economic outcomes. For example, high productivity firms may gain market shares and enjoy innovation rents in a still highly competitive environment. More broadly, recent research shows that these indicators are not unequivocally related to product market competition.[9] Furthermore, they fail to provide a direct link to policy or regulation, making it difficult to draw policy conclusions.

The empirical analysis presented in this chapter is, therefore, based on some of the potential policy determinants of competition rather than on direct measures of it. Specifically, the focus is on indicators of the stringency of product market regulations. The main effect of pro-competitive product market regulations is to strengthen the *incentives* to improve productivity and adopt new technologies.

Labour market institutions and productivity

Although labour market regulations are primarily designed to ensure socially desirable outcomes,[10] some of them can affect the costs of implementing measures aimed at improving efficiency. For example, restrictions on hiring and firing are often found to reduce incentives for internal efficiency by hindering the labour adjustments generally associated with such efforts.[11] At the same time, bargaining systems may affect the way rents associated with process and product innovation are appropriated by firms and workers. Systems that favour the sharing of innovation rents with workers (for instance by increasing the bargaining power of insiders or tying negotiations to enterprise performance) may inhibit innovative activity by reducing the expected returns from innovations; conversely, systems that favour the appropriation of rents by firms, for instance by co-ordinating individual bargaining processes at the industry or nation-wide level, and compressing wage structures so that wages are lower for skilled workers, may increase incentives to innovate (Teulings and Hartog, 1998).

Innovation, R&D and productivity

The direct effects of policy and institutions on MFP are likely to be combined with indirect effects stemming from their influence on R&D activity. First, R&D can boost productivity, either directly *via* the stream of innovation it produces,[12] or more indirectly *via* the adoption of existing technologies developed elsewhere.[13] This latter channel implies that the further a country is away from the technology frontier, the greater the benefits from R&D, by stimulating domestic and international knowledge spillovers. Second, there is evidence that interaction between strict EPL and certain industrial relations regimes, or certain aspects of product market regulations, have a detrimental effect on R&D activity.[14]

3.3. Empirical analysis

Direct determinants of productivity

The empirical analysis presented in this section focuses on industry-level multi-factor productivity. The latter offers a better proxy for the level of economic efficiency than labour productivity measures, especially in an

international comparison when differences in labour productivity may reflect differences in the labour intensity rather than differences in production efficiency (see Chapter 1). The productivity equation is derived from a theoretical framework in which MFP depends on country/industry specific factors, and on a catch-up term that measures the distance from the technological frontier (*i.e.* the most productive country) in each industry (see Box 3.2, and Annex 3 for further details). This framework permits testing for the direct effect of institutions and regulations on efficiency,[15] as well as for the indirect influences of these factors *via* the process of technology transfer.[16]

The empirical analysis covers 23 industries in manufacturing and business services in 18 OECD countries over the period 1984-1998.[17] The catch-up term, representing the distance from the technological frontier, is proxied by the difference between the MFP level in a particular industry and the highest level amongst countries for that industry. Albeit crude, this measure broadly confirms expectations about which countries and regions tend to be at the forefront of technology in certain fields (see Scarpetta and Tressel 2002 for details): the United States, Canada and Japan were often at the frontier in most industries over the period considered. However, if differences in hours worked are taken into account (as in the preferred measure of MFP), then a number of European countries were also close to the technology frontier. The comparison of MFP levels also suggests that in only a few cases does the identity of the frontier remain constant, which implies that some countries "leapfrogged" others in terms of technology leadership in most industries. However, what matters for productivity growth is the distance from the technological frontier – which captures the potential for technology transfer – rather than the identity of the frontier itself.

Table 3.1 presents the main results of the MFP regressions.[18] The technology-gap term (RMFP) is found to have a significant negative effect on MFP growth, suggesting that within each industry (with the exception of high-tech manufacturing industries, see below), countries that are further behind the frontier experience higher rates of productivity growth. However, confirming some previous results (*e.g.* Bernard and Jones, 1996a, b), there is evidence of a more rapid technological catch-up in service industries than in manufacturing. This is true both in terms of short-term technological "pass through" (*i.e.* the coefficient of MFP growth in the leader country, ΔMFP_{leader}), which is statistically insignificant for manufacturing industries, as well as over the longer run as shown by the higher coefficient on the technology-gap term for services. This is consistent with the view that convergence is relatively easier when technology is more standardised, as in many service sectors, than in cases where it is more diversified, as in many manufacturing industries.

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Box 3.2. **The estimated multi-factor productivity equation**

The cross-country, cross-industry analysis of productivity is centred around a catch-up specification of productivity where, within each industry, the production possibility set is influenced by technological and organisational transfer from the technology-frontier country to other countries. In this context, multi-factor productivity (MFP) for a given industry *j* of country i (MFP_{ijt}) can be modelled as an auto-regressive distributed lag process in which the level of MFP is co-integrated with the level of MFP of the technological frontier country F: Formally,

$$\ln MFP_{ijt} = \beta_1 \ln MFP_{ijt-1} + \beta 2 \ln MFP_{Fjt} + \beta 3 \ln MFP_{Fjt-1} + \omega_{ijt} \qquad [3.1]$$

where ω stand for all observable and non-observable factors influencing the level of MFP. Under the assumption of long-run homogeneity ($1 - \beta_1 = \beta_2 + \beta_3$) and rearranging equation [3.1] yields the convergence equation:

$$\Delta \ln MFP_{ijt} = \beta_2 \Delta \ln MFP_{Fjt} - (1 - \beta_1) RMFP_{ijt-1} + \omega_{ijt} \qquad [3.2]$$

where $RMFP_{ijt} = \ln(MFP_{ijt}) - \ln(MFP_{Fjt})$ is the technological gap between country i and the leading country F. Multi-factor productivity, MFP_{ijt}, is measured as the Hicks neutral productivity parameter, according to a standard neo-classical production technology under constant returns to scale. The computation of MFP growth ($\Delta \ln MFP_{ijt}$) is similar to that adopted in previous chapters, *i.e.* it is equal to the change in gross output less the share weighted changes in inputs. The calculation of the technological gap variable in 3.2 requires estimates of the level of MFP in a given industry/country and year. This is obtained by first calculating the level of MFP in each country relative to a common reference point (the geometric average of all countries) (see Harrigan, 1999):

$$MFP_{ijt} = \frac{Y_{ijt}}{\overline{Y}_{jt}} \cdot \left(\frac{\overline{L}_{jt}}{L_{ijt}} \right)^{\alpha_{ijt}} \cdot \left(\frac{\overline{K}_{jt}}{K_{ijt}} \right)^{1-\alpha_{ijt}} \qquad [3.3]$$

where a bar denotes a geometric average over all the countries for a given industry *j* and year t. The technological frontier is defined as the highest value of MFP relative to the geometric average in each industry *j* in the year t and the technological gap ($RMFP_{ij}$) is the difference between the level of MFP and the frontier level in each industry and year. However, the comparison of productivity levels also requires the conversion of underlying data into a common currency, while also taking into account differences in purchasing powers across countries.[1]

Box 3.2. **The estimated multifactor productivity equation** *(cont.)*

The technology gap variable relates to the aggregate convergence literature discussed in Chapter 2. Specifically, it allows tests of whether convergence – generally found in macro analyses – is driven by specialisation between industries and/or convergence within industries (see Dollar and Wolff, 1988, 1993). The residual in equation [3.2] is modelled as follows:

$$\omega_{ijt} = \sum_k \gamma_k V_{kijt-1} + f_i + g_j + d_t + \varepsilon_{ijt} \qquad [3.4]$$

where (V_{ijt}) is a vector of covariates (*e.g.* product and market labour regulations) affecting the level of MFP; f_i , g_j, and d_t are respectively country, industry and year fixed effects. ε is an *iid* shock. Moreover, equation 3.2 can be solved for steady-state MFP in country *i* relative to the frontier in industry *j*, which gives insights on the effects of these country and/or country-industry-specific factors on the steady-state level of MFP.

1. The analysis in this paper uses industry-specific expenditure PPPs, but the sensitivity analysis also tests the robustness of results by using aggregate PPPs.

The policy-augmented productivity regressions clearly show a strong influence of product and labour market regulations on industry productivity (see Box 3.3 for details on the regulatory indicators). In particular, there is a negative direct effect of product market regulations on productivity, whichever indicator is considered.[19] However, if the interaction of regulation with the technology gap is also considered (variable PMR^*RMFP_{ijt-1} in equations E to H), the results indicate a statistically more significant indirect effect of regulations on productivity *via* a slower adoption of existing technologies: strict regulations seem to have a particular detrimental effect on productivity the further the country is from the technology frontier, possibly because they reduce the scope for knowledge spillovers.

The analysis is also extended to consider the industrial relations regimes[20] and summary indicators of employment protection legislation that proxy the cost of labour adjustment. The results suggest that different industrial relations regimes do not matter *per se* (the variables related to corporatism (the bargaining system) are not significant in equation L and onwards), but they may, nevertheless, negatively affect productivity *via* their interactions with EPL. Indeed, there is evidence that the negative impact of EPL on productivity (shown by equation K) only applies to countries with an intermediate degree of centralisation/co-ordination, *i.e.* where sectoral wage bargaining is predominant without co-ordination. By contrast, EPL is not

Table 3.1. Productivity regressions: the role of regulations and institutions

	A	B	C	D	E	F	G	H	I	J
Constant	–0.002	–0.004	–0.004	–0.004	–0.019*	–0.018*	–0.015	–0.015	–0.026**	–0.026**
	(0.010)	*(0.010)*	*(0.010)*	*(0.010)*	*(0.011)*	*(0.010)*	*(0.011)*	*(0.011)*	*(0.011)*	*(0.011)*
Δ TFP$_{Leader\ j\ t}$ (MAN)	–0.013	–0.013	–0.013	–0.013	–0.012	–0.012	–0.012	–0.012	–0.012	–0.012
	(0.009)	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.008)*	*(0.008)*
Δ TFP$_{Leader\ j\ t}$ (SERV)	0.082***	0.085***	0.081***	0.084***	0.079***	0.098***	0.079***	0.078***	0.081***	0.080***
	(0.013)	*(0.013)*	*(0.014)*	*(0.013)*	*(0.014)*	*(0.014)*	*(0.015)*	*(0.014)*	*(0.018)*	*(0.018)*
RTFP$_{i\ j\ t-1}$(MAN)	–0.023***	–0.023***	–0.024***	–0.024***	–0.048***	–0.045***	–0.042***	–0.047***	–0.042***	–0.046***
	(0.004)	*(0.004)*	*(0.005)*	*(0.005)*	*(0.009)*	*(0.008)*	*(0.008)*	*(0.012)*	*(0.009)*	*(0.011)*
RTFP$_{i\ j\ t-1}$ (SERV)	–0.048***	–0.049***	–0.047***	–0.048***	–0.073***	–0.060***	–0.064***	–0.070***	–0.064***	–0.066***
	(0.008)	*(0.008)*	*(0.008)*	*(0.008)*	*(0.011)*	*(0.009)*	*(0.010)*	*(0.013)*	*(0.013)*	*(0.013)*
PM regulations (PMR)	–0.007***				0.004					
	(0.002)				*(0.003)*					
PMR (sectoral)		–0.030**				0.023				
		(0.012)				*(0.015)*				
PMR (economic regulation)			–0.004***				0.002			
			(0.001)				*(0.002)*			
PMR (time-varying)				–0.003***				–0.0004		
				(0.001)				*(0.001)*		
PMR * RTFP$_{i\ j\ t-1}$					0.016***				0.009*	
					(0.005)				*(0.006)*	
PMR (sectoral) * RTFP$_{i\ j\ t-1}$						0.086***				
						(0.027)				
PMR (econ. reg.) * RTFP$_{i\ j\ t-1}$							0.009***			
							(0.003)			
PMR (time-varying) * RTFP$_{i\ j\ t-1}$								0.005**		0.004*
								(0.002)		*(0.002)*
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	No	No	No	No	No	No	No	No	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3 191	3 191	3 191	3 191	3 191	3 191	3 191	3 191	3 191	3 191

Table 3.1. **Productivity regressions: the role of regulations and institutions** *(cont.)*

	K	L	M	N	O	P	Q	R	S	T
Constant	–0.008	–0.012	–0.018	–0.018	–0.010	–0.001	–0.010	–0.011	–0.011	–0.014
	(0.010)	*(0.010)*	*(0.013)*	*(0.011)*	*(0.012)*	*(0.013)*	*(0.010)*	*(0.010)*	*(0.009)*	*(0.009)*
Δ TFP$_{Leader\,j\,t}$ (MAN)	–0.013	–0.012	–0.012	–0.012	–0.012	–0.012	–0.012	–0.012	–0.012	–0.012
	(0.009)	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*	*(0.009)*
Δ TFP$_{Leader\,j\,t}$ (SERV)	0.085***	0.083***	0.078***	0.093***	0.077***	0.074***	0.078***	0.090***	0.077***	0.075***
	(0.013)	*(0.014)*	*(0.015)*	*(0.015)*	*(0.015)*	*(0.014)*	*(0.014)*	*(0.014)*	*(0.015)*	*(0.014)*
RTFP$_{i\,j\,t-1}$(MAN)	–0.024***	–0.023***	–0.042***	–0.040***	–0.036***	–0.041***	–0.037***	–0.035***	–0.037***	–0.047***
	(0.005)	*(0.005)*	*(0.009)*	*(0.008)*	*(0.008)*	*(0.012)*	*(0.007)*	*(0.007)*	*(0.007)*	*(0.011)*
RTFP$_{i\,j\,t-1}$ (SERV)	–0.049***	–0.049***	–0.067***	–0.057***	–0.058***	–0.062***	–0.062***	–0.055***	–0.058***	–0.069***
	(0.008)	*(0.008)*	*(0.012)*	*(0.009)*	*(0.010)*	*(0.013)*	*(0.010)*	*(0.009)*	*(0.009)*	*(0.012)*
High corporatism		–0.002	–0.001	–0.002	–0.001	–0.003	–0.002	–0.002	–0.001	–0.002
		(0.003)	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*
Low corporatism		–0.001	–0.001	–0.001	–0.002	–0.007*	–0.002	–0.002	–0.002	–0.004
		(0.003)	*(0.003)*	*(0.003)*	*(0.003)*	*(0.004)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*
EPL (high corporatism)		–0.002	–0.002	–0.002	–0.002	–0.001	–0.001	–0.001	–0.002	–0.002
		(0.003)	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*
EPL (medium corporatism)		–0.010***	–0.008***	–0.008***	–0.008***	–0.007***	–0.007***	–0.008***	–0.008***	–0.009***
		(0.002)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*
EPL (low corporatism)		0.0005	0.001	0.001	0.003	0.004*	0.002	0.002	0.003*	0.002
		(0.001)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*
EPL	–0.002**									
	(0.001)									
PM regulations (PMR)			0.004							
			(0.004)							
PMR (sectoral)				0.023						
				(0.018)						
PMR (economic regulation)					–0.0002					
					(0.003)					

Table 3.1. **Productivity regressions: the role of regulations and institutions** *(cont.)*

	K	L	M	N	O	P	Q	R	S	T
PMR (time-varying)						–0.003				
						(0.002)				
PMR * $RTFP_{ijt-1}$			0.012**				0.009**			
			(0.005)				*(0.004)*			
PMR (sectoral) * $RTFP_{ijt-1}$				0.064**				0.047**		
				(0.027)				*(0.022)*		
PMR (econ. reg.) * $RTFP_{ijt-1}$					0.006**				0.007**	
					(0.003)				*(0.003)*	
PMR (time-varying) * $RTFP_{ijt-1}$						0.004*				0.005**
						(0.002)				*(0.002)*
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	No	No	No	No	No	No	No	No	No	No
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3 191	3 191	3 191	3 191	3 191	3 191	3 191	3 191	3 191	3 191

Notes: In all equations with (time invariant) product market regulatory indicators, standard errors are adjusted for cluster level effects. Robust standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1 % level.

Source: OECD.

Box 3.3. **Indicators of the stringency of product market regulations and employment protection legislation**

In the empirical analysis, three types of indicators of product market regulations and one on particular aspects of labour market regulations are considered (for more details, see Scarpetta *et al.*, 2002).

The overall index of the stringency of product market regulation (PMR) is a static indicator computed for the year 1998. It consists of three elements: *i)* direct state control of economic activities, through state shareholdings or other types of intervention in the decisions of business sector enterprises and the use of command and control regulations; *ii)* barriers to private entrepreneurial activity, through legal limitations on access to markets, or administrative burdens and opacities hampering the creation of businesses; and *iii)* regulatory barriers to international trade and investment, through explicit legal and tariff provisions or regulatory and administrative obstacles (see Nicoletti *et al.*, 1999 for more details). The indicator has a wide coverage of regulatory aspects, but neither industry nor time dimension. In order to further characterise the regulatory settings, this indicator is further split into two components: economic regulations (state control, legal barriers to entry, etc.) and administrative regulations (administrative burdens on start-ups, features of the licensing and permit system, etc.).

The industry-specific indicator of product regulation (PMR sectoral) is also a static indicator (1998), but it varies across service-sector industries (retail and wholesale trade; transport and communication; financial intermediation and business services). The indicator always includes barriers to entrepreneurial activity and public ownership, while for certain industries it also considers other aspects of regulation. For the manufacturing industries, for which no specific information on regulations is available, the economy-wide indicator of administrative regulations is used as a proxy in the construction of this sector-specific indicator.[1]

The aggregate time-varying indicator of the stance of regulation (PMR time-varying) is a simple average of time-varying indicators of the stringency of regulations in *electricity and gas*, as well as in *transport and communication*. This average is used to proxy the overall stance of regulatory reform in each OECD country. Its clear advantage in the empirical analysis is the time dimension but, given that it only covers certain (albeit key) service industries, it should be considered as a first approximation of the economy-wide regulatory reform stance of OECD countries (see Nicoletti *et al.*, 2001 for more details).

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Box 3.3. **Indicators of the stringency of product market regulations and employment protection legislation** *(cont.)*

The indicators of employment protection legislation are available for two periods (late 1980s and 1998) and focus on both regular and temporary contracts (see Nicoletti *et al.* 1999). Regulations for regular contracts include: *i)* procedural inconvenience that employers face when trying to dismiss a worker; *ii)* advance notice of dismissal and severance payments; and *iii)* prevailing standards of, and penalties for, "unfair" dismissals. Indicators of the stringency of EPL for temporary contracts include: *i)* the "objective" reasons under which they can be offered; *ii)* the maximum number of successive renewals; and *iii)* the maximum cumulated duration of the contract. The EPL indicator used in the econometric analysis is time-varying, with the shift in regime from the late 1980s stance to that of 1990s being defined on the basis of information about the timing of major EPL reforms (concerning both temporary and regular workers) in OECD countries.

1. The indicator of administrative regulations is used as a proxy instead of the overall indicator of product market regulations because it refers to norms and regulations that are applied to all industries, while the overall indicator also includes economic regulations, some of which are more sector-specific and do not apply to manufacturing industries.

found to influence productivity in either highly centralised/co-ordinated or decentralised countries. One potential explanation is that technological change is often associated with skill upgrading of the workforce. The required adjustment of the workforce can be achieved either using the internal labour market *via* firm-sponsored training if EPL is strict, or by acquiring the necessary skills on the external labour market. In this context, strict EPL raises the costs of adjusting the workforce. The implied detrimental effect on technology adoption may be magnified in the intermediate regime, where the costs of adjusting the workforce are sufficiently high to deter firms from using the external labour market, while at the same time the lack of co-ordination does not offer them the required institutional device to guarantee a high return on internal training, because other firms can poach on their skilled workforce by offering higher wages.[21]

The empirical results can be restated in terms of the potential effects of policy reforms on the long-run level of multifactor productivity.[22] Bearing in mind the illustrative nature of such an exercise, a reduction in the stringency of product market regulations is estimated to substantially reduce the productivity gap in countries such as Greece, Portugal and Spain over the longer run. This assessment only takes into account the indirect effect of regulatory reform on the process of technology adoption, but does not include

the potential effect of such a reform on increased R&D activity. An easing of employment protection legislation may also significantly boost productivity, at least in countries – such as Belgium, France or Portugal – where the adjustments costs associated to EPL are not offset by the possibility of adjusting wages or use of internal training.

Another topic of interest relates to the possible influence of sector- or market-specific conditions on the productivity generating process. This issue can be investigated using manufacturing data, for which appropriate statistical information on market structures and technology regimes can be computed. As detailed in Box 3.4, manufacturing industries may be classified into two broad categories: low-tech (LT in Table 3.2) and high-tech industries (HT). Table 3.2 presents the (preferred) equations estimated to explore whether the productivity impact of the technology gap, and also that of R&D, depend on these technology regimes and market characteristics. The results point to a strong and highly significant effect of the technology catch-up for LT industries, while this effect is not statistically significant in high-tech industries. However, this latter group is rather heterogeneous and equation I in the table further decomposes it into two groups: high concentration (HTHC) and low concentration (HTLC). The results suggest a significant convergence in high-concentrated high-tech industries, but no convergence in low-concentrated industries. These findings are consistent with the idea that industries operating in low-tech industries tend to share the same technology, so that spillover effects may be significant. In contrast, such spillover effects are likely to be less marked when the evolution of technology stimulates product or process diversification, as is the case in industries operating in a monopolistic competition regime (HTLC).

The results also enable refinement of the analysis of the links between policy and institutional variables and productivity. In particular, the inclusion of R&D in the productivity equation for manufacturing implies that the *direct* effect of product market regulations is only marginally significant (equation E) and, if control EPL is also included, the effect is no longer statistically significant. However, the *indirect* effect via the technology gap remains significant.

Table 3.2 also indicates a differentiated effect of R&D on productivity, depending on the technology regime.[23] Indeed, if allowed to vary between low- and high-tech industries, the estimated effect of R&D becomes insignificant in the latter. As in the case of technology convergence, however, this result hides a different behaviour of industries depending on whether their technology regime leads to low or high concentration (see last column of Table 3.2). Indeed, there is no significant effect of R&D on productivity in low-concentrated high-tech industries, but a strong effect in high-concentrated industries. High-tech industries with low concentration are often

characterised by "creative destruction" with technological ease of entry and a major role played by new firms in innovative activities (see also Nelson and Winter, 1982). Thus, returns on R&D in these industries may not be long-lasting, and R&D is likely to be driven by the need to engage in (perceived) product differentiation to maintain/acquire market shares. In this context, high R&D intensity may not necessarily result in higher *measured* productivity, unless quality differentiation is taken into account in measuring industry value-added, which is the case of only a few industries in a very few countries.[24] By contrast, high-tech but concentrated industries are generally characterised by "creative accumulation", with the prevalence of large, established firms and the presence of barriers for new innovators. Returns to R&D in these industries are, therefore, likely to be larger than in low concentration ones, possibly leading to persistent technological leadership.[25] This latter point is reinforced by the positive sign of the interaction term between R&D and the technology gap. This implies greater returns from R&D of leading firms compared with followers. Indeed, knowledge and technological progress is strongly cumulative in these industries, often providing the technological leader with a "first-mover advantage" in the introduction of innovations.

Indirect determinants of multi-factor productivity via R&D activity

Albeit differentiated by technology regimes, the empirical analysis presented in the previous section has clearly indicated the importance of R&D activity for productivity. It is, therefore, important to assess whether regulation and institutional settings also influence productivity indirectly via their impact on R&D activity.[26] As discussed above, both theoretical and empirical studies lend some support to the idea that, for a given level of property rights, strict regulatory settings that undermine competition may curb incentives to engage in innovation. Likewise, a few studies have argued that high costs of adjusting the workforce may have important consequences for the profitability of firms' innovative strategies.

A simple model of the determinants of innovative effort relates the latter to expected profit differential – *i.e.* the expected difference between profits that the firm can earn once it has successfully innovated, and those that would be earned otherwise.[27] Regulations in both product and labour markets may affect the expected profit differential. Hence, taking the ratio of business-performed R&D expenditure to sales (hereafter R&D intensity) as the indicator of innovative activity, a reduced-form R&D equation can be expressed as a function on regulations and a set of other control variables (such as human capital or the degree of protection of intellectual property rights).

The indicators of product market regulation include measures of state control and administrative regulation (administrative barriers on start-ups,

Table 3.2. **Productivity regressions: the role of R&D, market structure and regulatory settings – Manufacturing**

Dependant variable: ΔTFP_{ijt}	A	B	C	D	E	F	G	H	I
Constant	−0.030**	0.018	0.029*	0.035***	0.004	0.002	0.016	0.004	0.047
	(0.013)	*(0.015)*	*(0.016)*		*(0.018)*	*(0.013)*	*(0.015)*	*(0.020)*	*(0.031)*
$\Delta TFP_{Leader\,j\,t}$	−0.007	−0.007	−0.007	0.001	−0.005	−0.005	−0.005	−0.005	
	(0.008)	*(0.009)*	*(0.009)*	*(0.009)*	*0.009*	*(0.009)*	*(0.008)*	*(0.008)*	
$\Delta TFP_{Leader\,j\,t}$ (HTLC)									0.096
									(0.062)
$\Delta TFP_{Leader\,j\,t}$ (HTHC)									−0.014
									(0.011)
$RTFP_{i\,j\,t-1}$	−0.029***	−0.029***	−0.019**						
	(0.004)	*(0.005)*	*(0.009)*						
$RTFP_{i\,j\,t-1}$ (LT)				−0.020***	−0.050***	−0.060***	−0.036***	−0.053***	
				(0.004)	*(0.016)*	*(0.011)*	*(0.006)*	*(0.012)*	
$RTFP_{i\,j\,t-1}$ (HT)				−0.006	0.007	−0.023	−0.005	−0.019	
				(0.004)	*(0.015)*	*(0.018)*	*(0.014)*	*(0.017)*	
$RTFP_{i\,j\,t-1}$ (HTLC)									−0.053
									(0.056)
$RTFP_{i\,j\,t-1}$ (HTHC)									0.052***
									(0.015)
$R\&D_{i\,j\,t-1}$		0.006***	0.009***						
		(0.002)	*(0.003)*						
$R\&D_{i\,j\,t-1}$ (LT)				0.004***	0.004	0.004***	0.004**	0.004**	
				(0.001)	*(0.003)*	*(0.002)*	*(0.002)*	*(0.002)*	
$R\&D_{i\,j\,t-1}$ (HT)				0.004*	0.014**	0.007	0.007	0.007	
				(0.002)	*(0.006)*	*(0.007)*	*(0.006)*	*(0.006)*	
$R\&D_{i\,j\,t-1}$ (HTLC)									0.00004
									(0.017)
$R\&D_{i\,j\,t-1}$ (HTHC)									0.025***
									(0.009)
$(R\&D * RTFP)_{i\,j\,t-1}$			0.003						
			(0.003)						

Table 3.2. **Productivity regressions: the role of R&D, market structure and regulatory settings – Manufacturing** *(cont.)*

Dependant variable: ΔTFP_{ijt}	A	B	C	D	E	F	G	H	I
$(R\&D * RTFP)_{i\,j\,t-1}(LT)$					–0.002				
					(0.003)				
$(R\&D * RTFP)_{i\,j\,t-1}(HT)$					0.012*	0.007	0.005	0.006	
					(0.006)	*(0.007)*	*(0.006)*	*(0.006)*	
$(R\&D * RTFP)_{i\,j\,t-1}(HTLC)$									–0.011
									(0.024)
$(R\&D * RTFP)_{i\,j\,t-1}(HTHC)$									0.021***
									(0.007)
PM regulations (PMR)						0.007*		0.007	
						(0.004)		*(0.006)*	
$PMR * RTFP_{i\,j\,t-1}$						0.016**		0.011*	
						(0.007)		*(0.007)*	
High corporatism							–0.005	–0.004	
							(0.004)	*(0.004)*	
Low corporatism							–0.003	–0.002	
							(0.005)	*(0.005)*	
EPL (medium corporatism)							–0.010***	–0.009***	
							(0.003)	*(0.003)*	
EPL (low corporatism)							0.0004	0.0002	
							(0.002)	*(0.003)*	
EPL (high corporatism)							0.007	0.006	
							(0.005)	*(0.005)*	
Industry dummies	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reset	0.79	1.57	2.34*	0.77	1.74	2.87**	3.73**	3.21**	12.75***
Observations	2 569	2063	2063	2063	2063	2063	2063	2063	932

Notes: In all equations with (time invariant) product market regulatory indicators, standard errors are adjusted for cluster level effects. Robust standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1 % level.
Source: OECD.

Box 3.4. **A taxonomy of manufacturing industries according to their technology regimes**

The industrial organisation literature suggests three main elements characterising market conditions across industries. First, differences in market power may relate to differences in entry barriers, due to exogenous technological conditions such as economies of scale (see *e.g.* Panzar, 1989) and scope (Baumol *et al.*, 1982). Second, it has been argued that entry barriers may result from high sunk costs rather than from economies of scale. Finally, more recent research has focused on horizontal and vertical product differentiation (Eaton and Lipsey, 1989). Products can be considered as differentiated vertically when consumers can rank them by quality, otherwise they can be viewed as differentiated horizontally.

In practice, the possible combinations of these three dimensions, according to their relative importance, lead to a reduced number of market structure prototypes. In practical terms, Sutton (2000) offers a simple market structure classification into three categories, based on the returns to innovation and the degree of market concentration:

- Low-tech industries (LT): if the returns to innovation are low, investment in R&D will be low, and the industry will typically produce fairly standardised goods with little or no monopoly rents. This configuration is indicated by LT in the equations presented in Table 3.2.
- High-tech industries, low concentration (HTLC): if the returns to innovation are high, firms will invest heavily in technologies that improve process and products. However, if the evolution of technology leads to alternative types of products (product differentiation) or processes, there will typically be a large number of producers, each with some market power but little monopoly rents due to free entry of new firms to produce new (differentiated) products. Such market structure comes close to so-called (Chamberlain's) monopolistic competition. The motor vehicle industry may be considered a good example of such type of manufacturing industry.
- High-tech industries, high concentration (HTHC): in contrast to the previous case, if high returns to innovation can only be attained along a single trajectory, (high-tech) firms will inevitably move towards a highly-concentrated market structure, in which a small number of players dominate the market. Parts of the information and communication technology industry (*e.g.* software) may be considered good examples of this type of manufacturing industry.

Box 3.4. **A taxonomy of manufacturing industries according to their technology regimes** *(cont.)*

The nature of competition, the impact of given policy and institutional settings and, ultimately, economic performance may vary across these different market structures. For example, high mark-ups could be taken as a sign of market power in industries with low R&D, although they may well be an indication of innovation rents in those with high R&D (Oliveira Martins and Scarpetta, 1999). Similarly, high R&D expenditure may not result in high productivity growth, but rather in higher market shares in markets with highly differentiated products.

feature of the licensing and permit system, etc), indicators of tariff and non-tariff barriers, plus an indicator of global protection of intellectual property rights (IPRs).[28] Import penetration is used as a proxy for competitive pressures not captured by the regulatory indicators. A control for the average size of firms captures the possible bias in R&D intensity across industries and countries due to different accounting practices between large and small firms and has been proved to play an important role in the literature (see *e.g.* Griliches, 1990, Geroski, 1990).

Choosing a log-linear form for convenience, the R&D equation can be expressed as follows:

$$\log R\&D_{ij} = \alpha + \sum_h \gamma_h PMR^h_{ij} + \phi IMP_{ij} + \delta SIZE_{ij} + \mu_i + \chi_j + \varepsilon_{ij} \qquad [3.5]$$

where the dependent variable is the average *R&D intensity* in a given country/industry, *IMP* and *SIZE* denote import penetration and average size, μ stands for the country dummy, χ stands for the industry dummy, ε is the standard error term, while *h*, *i* and *j* index product market regulatory indicators, countries and industries, respectively.

Equation [3.5] is estimated on a cross-section of 18 manufacturing industries in 18 OECD countries.[29] The choice of a cross-section – rather than panel data, as in the case of the productivity equation – is justified by the need to include a set of control variables for which the time dimension is lacking, including certain aspects of product market regulations. The underlying data are the same as those used in the MFP equation above, except that here all variables have been averaged across the period 1993-1997.[30] In addition, industrial relations and technology regimes are considered, in order to explore the potential interactions between these two variables and employment protection legislation in explaining *R&D* expenditures.

The results are presented in Table 3.3. The estimated models account for the effects of EPL, industrial relations regimes and their potential interactions,

Table 3.3. **The effects of policies and institutions on R&D intensity**

Results of panel regressions

Dependent variable: R&D intensity[1]	No policy interactions			Policy interactions	
	A	B	C	D	E
Employment share of large firms[1]	1.39***	1.66**	1.66***	1.66***	1.58***
	(0.41)	(0.69)	(0.36)	(0.36)	(0.36)
Import penetration[1]	0.39***	0.34***	0.34***	0.34***	0.34***
	(0.11)	(0.08)	(0.12)	(0.12)	(0.12)
Non-tariff barriers	–0.02***	–0.03**	–0.03***	–0.03***	–0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tariff barriers[1]	0.18**	–0.04	–0.04	–0.04	–0.06
	(0.09)	(0.06)	(0.10)	(0.11)	(0.10)
State control		–0.42**	–0.42***	–0.42***	–0.40***
		(0.16)	(0.08)	(0.08)	(0.08)
Barriers to entrepreneurship		0.75***	0.75***	0.75***	0.74***
		(0.21)	(0.09)	(0.10)	(0.09)
EPL		–0.29	–0.29***	–0.29***	
		(0.18)	(0.08)	(0.10)	
Bargaining coordination		0.21	0.21***	0.19	
		(0.18)	(0.08)	(0.13)	
EPL*Bargaining coordination				0.01	
				(0.09)	
EPL in high-tech industries					–0.48***
					(0.13)
EPL in low-tech industries					–0.16
					(0.11)
Bargaining coordination in high-tech industries					–0.34*
					(0.18)
Bargaining coordination in low-tech industries					0.73***
					(0.18)
EPL*Bargaining coordination in high-tech industries					0.23***
					(0.09)
EPL*Bargaining coordination in low-tech industries					–0.21***
					(0.08)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	No	No	No	No
Reset	1.95	2.07			
Observations	255	255	255	255	255
Countries	18	18	18	18	18

Notes: All equations include a constant. Robust standard errors are in brackets. *: significant at 10 % level; ** at 5% level; *** at 1 % level. Samples are adjusted for outliers. In equation B, standard errors are adjusted for cluster level effects. Equations C to E use random-effect estimators. High-tech industry corresponds to industries 24 and 29-35 of the ISIC Rev. 3 classification.

1. In logarithm.

Source: OECD.

but control also for outward and inward-oriented product market regulations (at both the industry and economy-wide levels). In addition, they control for firm size (the share of employment in large enterprises) and trade openness (proxied by import penetration).[31] All regressions also include industry dummies to control for unexplained industry characteristics (*e.g.* technological opportunity). Finally, the potential interaction between EPL, industrial relations regimes and the technological characteristics of different industries was dealt with by introducing a dummy variable that identifies high-technology industries (see above).

The empirical results confirm the positive association between recorded R&D intensity and the average size of firms in each industry. Moroever, R&D activity tends to increase with trade openness, perhaps pointing to the existence of positive knowledge spillovers. Indeed, trade openness tends to increase product variety in domestic markets and induces imitation by domestic producers and the latter often requires spending in R&D (Cohen and Levinthal, 1989). The degree of protection of IPRs also appears to be positively, and significantly, associated with R&D intensity in all specifications.[32]

Concerning the role of regulations, the results point to an unambiguous negative effect of non-tariff barriers and state control on R&D. By contrast, trade tariffs as well barriers to entrepreneurship are positively associated with R&D intensity. The different impact of tariffs and non-tariff barriers on R&D is consistent with some theoretical considerations. While from a partial equilibrium point of view trade restrictions tend to add to foreign competitors' costs without changing the incentive to innovate amongst domestic firms, in general equilibrium, they also curb imports and possible knowledge spillovers related to them. This latter effect is likely to be stronger for non-tariff barriers than for tariffs because they have greater impact on the diffusion of products and, eventually, the possibility of imitation by domestic firms.[33] The positive associations between barriers to entrepreneurship and R&D might be due to the fact that these barriers, by discouraging entry, may contribute to increasing *ex post* innovation rents and improving appropriability conditions, reinforcing the effect of IPRs protection.

R&D intensity also appears to decrease with the stringency of EPL and to increase with the degree of co-ordination. At the same time, no effect on R&D of the interaction between EPL and co-ordination in industrial relations can be found pooling all industries together. Results change, however, if separate coefficients for high- and low-technology industries are estimated: interaction terms now have significant and opposite effects on the two sets of industries. At any given level of EPL and co-ordination in industrial relations, their combination appears to have a positive effect on R&D intensity in high-tech industries and a negative effect in low-tech industries. The rationale for this result is that in low-tech industries the scope for expansion is often limited

and innovation often leads to downsizing and reshuffling of the workforce and may, therefore, be discouraged by legislation hindering labour adjustments. By contrast, in high-tech industries, co-ordination tends to partly offset the negative influence of EPL, by pushing firms towards greater recourse to in-house training.

To shed further light on this issue, Bassanini and Ernst (2002) further split high-tech industries into the two groups discussed above, a high-concentration (HTHC) and a low concentration group (HTLC). As discussed above, the former tends to be characterised by cumulative innovation processes, while the latter is characterised by frequent changes in technological trajectories. The main results concerning the impact of the interaction between EPL and co-ordination in these different types of industries are reported in Table 3.4. Hiring and firing restrictions generally have negative effects on innovative activity in low-tech industries and decentralised economies, but different effects in high-tech industries depending on the technological regime. No constraining role of EPL on R&D can be detected in high-technology industries characterised by a cumulative innovation process, supported by worker skills that are highly specific to individual firms (*e.g.* electronic components and aircraft). In these industries, the best worker competencies to complement innovations are often found within the firm, and upgrading skills of existing employees is likely to be less costly than training new workers.

Table 3.4. **Estimated effects of employment protection on R&D intensity**

Dependent variable: logarithm of R&D intensity		Type of industrial relations system	
		Low/ intermediate coordination	High coordination
Industry type			
	Low-tech industries	–0.16	–0.46**
		(0.20)	*(0.19)*
	HTLC	–0.38*	–0.11
		(0.21)	*(0.26)*
	HTHC	–0.37*	0.69**
		(0.21)	*(0.30)*

Note: Robust standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1 % level.
Source: Bassanini and Ernst (2002).

3.4. Concluding remarks

By assessing how specific policy and institutional settings in product and labour markets may have contributed to shape industry productivity growth, this chapter has sought to broaden the view of the link between policy and

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growth tackled in Chapter 2. Most prominently, there is evidence that stringent regulatory settings in the product market, as well as strict employment legislation, have a negative bearing on productivity at the industry – and, therefore, macro – levels. However, these policy influences are not straightforward, and depend on a number of factors.

The impact of regulations and institutions on performance varies, depending on the market and technology conditions in which it is operating. In particular, the burden of strict product market regulations on productivity seems to be greater the larger the technological gap with the industry/country leader: strict regulation hinders the adoption of existing technologies, possibly because it reduces competitive pressures or technology spillovers. In addition, strict product market regulations also have a negative impact on the process of innovation itself (insofar as it can be proxied by R&D expenditure). Thus, given the strong impact of R&D on productivity, there is also an indirect channel whereby strict product market regulations may reduce the scope for productivity enhancement.

The link between employment protection legislation and productivity is also complex. There is evidence to suggest that high hiring and firing costs weaken productivity performance, especially when they are not offset by wages and/or internal training, thereby inducing sub-optimal adjustments of the workforce to technology changes and innovation. These considerations are consistent with the firm-level evidence (see Ahn, 2001, for a survey) suggesting that the effects on productivity of innovation and adoption of new technologies are enhanced in firms with a highly-skilled workforce or with strong investment in training.

Finally, there is considerable variation in the effect of R&D activity on productivity, depending on market structures and technology regimes. For example, there is some support to the idea that strong R&D activity does not necessarily bring about higher productivity when firms are engaged in strong product differentiation and when there are different possible technology trajectories. In turn, the impact of hiring and firing costs on R&D depends on industrial relations and technology regimes. For example, while EPL adds to the negative effects on innovation of strict product market regulations in unco-ordinated countries and in low-tech industries, in high-tech industries with cumulative innovation process the effect is not marked.

These results offer some insights to the observed multi-factor productivity growth differentials seen at the aggregate level (see Chapter 1). Indeed, most of the countries having experienced a slow-down in multi-factor productivity growth during the 1990s are characterised by strict product market regulation, as well as by strict employment protection legislation combined with wage-settings that do not offset the associated high labour

adjustment costs. Moreover, the evidence concerning interactions between labour market policies, industrial relations systems and technological characteristics suggests that in countries with high bargaining co-ordination and relatively strict EPL (*e.g.* Germany, Austria), innovative activity is likely to thrive in industries characterised by a dominant technology and a cumulative innovation process. Countries that have a decentralised bargaining system and more lax EPL (*e.g.* the United States) are better equipped to innovate in industries characterised by multiple and rapidly-evolving technologies, including most of the ICT industry.

However, despite providing some clues to the reasons behind the different size of the ICT industry and, more generally, the widening gap in multi-factor productivity growth across OECD countries, this chapter has left unanswered a number of key issues. More specifically, it has not tackled the determinants of firms' behaviour, which has played a major role in enhancing technological progress over the recent period. Chapter 4 aims at filling this gap, by analysing the role of firm turnover for aggregate productivity growth and the main determinants of entry, exit and post-entry expansion of firms.

Notes

1. This chapter draws from Scarpetta and Tressel (2002).
2. The shift-share analysis is performed using the maximum industry decomposition available in ISDB-STAN: 3-4 digit ISIC for manufacturing (*i.e.* a 22 industry detail), and 2-digit ISIC for services. This decomposition bears several limitations other than the lack of detail for services (Timmer and Szirmai, 1999). First, it focuses on labour productivity and not on multi-factor productivity. Second, it assumes that marginal productivity of factor inputs moving in or out of an industry is the same as average productivity. Finally, if output growth is positively related to productivity growth (the so-called Verdoorn effect), the impact of structural change may be underestimated, since part of the shift to rapid-growth sectors will be counted in the within-effect.
3. It was particularly important in the United Kingdom in the 1980s, where it was linked to the decline of mining and manufacturing.
4. Given the limited disaggregation of the service sector available, it is possible that considerable structural changes occurring within some broadly defined industries (*e.g.* business services) pass unnoticed. However, further investigation using US data does not lend much support to this view. Indeed, to shed light on the sensitivity of the decomposition of between and within effects to changes in the industry details, the shift-share analysis was replicated for the United States with three different industry breakdowns provided by the Bureau of Economic Analysis: 1) 1-digit data; 2) details for manufacturing but broad aggregates for services and mining (i.e. close to the decomposition used in the text); and 3) the maximum detail of 58 industries. The results did not show a high sensitivity of the decomposition to the degree of industry detail used, confirming the strong role of within-industry changes in productivity in explaining aggregate patterns.

5. It should be stressed, however, that there are many dimensions of intellectual property rights legislation, some of which could have ambiguous effects on R&D activity. See OECD (2001a) for more details.
6. For a brief overview of existing studies, see Scarpetta and Tressel (2002).
7. For cross-country studies that explore the role of competition on productivity using mark-ups and concentration indexes, see Cheung and Garcia Pascual (2001).
8. For studies using firms' market shares, see Nickell (1996), Nickell *et al.* (1997) and Disney *et al.* (2000).
9. For example, Boone (2000a) suggests that there may be a hump-shaped relationship between competition and mark-ups.
10. For instance, well-designed policies can provide insurance against the risk of job loss, improve matching and commitment in worker-firm relationships and encourage skill upgrading.
11. See amongst others, Audretsch and Thurik (2001), Caroli *et al.* (2001), Hobjin and Jovanovic (2001).
12. This is the main assumption behind most theoretical and empirical studies, which both emphasise the importance of R&D for productivity (see *e.g.* Griliches, 1990; Griliches and Lichtenberg, 1984; and recently Guellec and van Pottelsberghe, 2001).
13. See for instance Cohen and Levinthal (1989) or Griffith *et al.* (2000).
14. See Soskice (1997), Eichengreen and Iversen (1999), Acemoglu and Pischke (1999a,b).
15. As shown in Box 3.2, product market regulations are assumed to affect the level, not the growth rate, of MFP.
16. For example, if the adoption of new technologies relies partly on new firms, high entry barriers may reduce the pace of adoption (see *e.g.* Boone, 2000b).
17. See Annex 5 for a detailed presentation of countries, industries and data sources.
18. As indicated by equation [3.4] in Box 3.2, all equations control for country, industry and year fixed effects. Since there is evidence of heteroscedasticity in the data, the Huber-White-Sandwich estimator is used for standard errors. All equations exclude a number of outlier observations identified on the basis of the DFIT and COVRATIO statistical tests. These observations significantly increase the standard error of the regression, or affect the estimated coefficients (see Chatterjee and Hadi, 1988). For further details on econometric issues involved in the equations presented in this chapter (model selection, residual tests, specification tests, identification of outliers, etc.), see Scarpetta and Tressel (2002).
19. These results are broadly consistent with those of other studies by Blundell *et al.* (1995, 1999), Nickell (1996) and Cheung and Garcia Pascual (2001).
20. The summary indicator of the *bargaining system (corporatism)* combines two variables: *i)* the level of bargaining: centralised, intermediate (at sector or regional), or decentralised (firm level); and *ii)* the degree of co-ordination amongst, on the one hand, employers' associations and, on the other, trade unions. This combined variable allows consideration of cases where co-operation between employers and unions in an industry bargaining setting (*e.g.*, Germany and Austria and, more recently, Italy, Ireland, the Netherlands with the income policy agreements) may be an alternative, or functionally equivalent, to centralised

systems, thereby mimicking their outcomes. In the table, the two variables referring to corporatism indicate the effects of high/low centralisation/co-ordination with respect to that of an intermediate system. The distribution of countries according to the different aspects of collective bargaining and changes over time is presented in Elmeskov, Martin and Scarpetta (1998).

21. Unlike decentralised or intermediate – *i.e.* where sectoral wage-bargaining is predominant without co-ordination – regimes, a centralised and/or co-ordinated bargaining system offers an institutional device that discourages poaching, and thus favours internal training: *i)* contracts tend to cover a large fraction of employers and workers in most industries with limited room for differences in wage offers across industries which, in turn, reduces incentives for highly-skilled workers to change job (Teulings and Hartog, 1998; Acemoglu and Pischke, 1999a); *ii)* in such a regime, poaching may be considered as unfair behaviour (Blinder and Krueger, 1996; Casper *et al.*,1999); and finally *iii)* the cost of training is often shared among employers when business associations have a prominent role (Soskice, 1997, Casper *et al.*, 1999).

22. See Annex 3 for details.

23. It should be stressed that despite the large number of studies, the links between R&D activity and market structure remain the subject of intense discussion (see, amongst others, Symeonidis, 1996 for a survey).

24. See Annex 1. However, even if quality differences could be fully measured, firms in highly product-differentiated markets may still be caught in a process of R&D escalation, leading to a rise in R&D expenditures but not necessarily higher productivity (Sutton, 1996).

25. These two groups of high-tech industries have also been labelled Schumpeterian Mark I and Mark II industries (see Malerba and Orsenigo, 1995, 1997, for an exhaustive characterisation of these technological regimes). See Scarpetta *et al.*, 2002 for details on the separation of industries into these two groups.

26. For all details on the issues and results treated below, see Bassanini and Ernst (2002).

27. See *e.g.* Aghion *et al.* (2001a); Boone (2000b); Aghion *et al.* (2001b).

28. The indicator of IPR is based on national intellectual property legislation as calculated by Ginarte and Park (1997). They use five point score based on the sum of five national components: *i)* τηε extent of coverage (pharmaceuticals, food, etc.); *ii)* membership in international agreements; *iii)* loss of protection (compulsory license provisions, etc.); *iv)* enforcement mechanisms (provisions for injunctions, pleadings, etc.); and *v)* duration of protection. Walter Park kindly provided these data.

29. See Bassanini and Ernst (2002) and Nicoletti *et al.* (2001) for more details.

30. The very few exceptions to this rule are detailed in Bassanini and Ernst (2002).

31. Firm size is often found to correlate with R&D intensity, but the direction of causation is unclear. This link may simply be the outcome of different accounting practices between large and small firms (Griliches, 1990), but it could also reflect the fact that successful innovation typically leads to larger firm size (Dasgupta and Stiglitz, 1980; Levin and Reiss, 1984; and Sutton, 1998). In any event, it is important to stress that all the results described below are essentially robust to the elimination of the control for firm size from the estimated model specification.

32. Results concerning protection of IPRs must be taken with care as the coefficient of this variable is likely to be overestimated due to the endogeneity of the indicator to the level of R&D expenditure (see Ginarte and Park, 1997).

33. Moreover, high non-tariff barriers can be thought to affect directly the elasticity of substitution between imported and domestically-produced products, thereby inducing low incentives to innovate when domestic and foreign firms have similar levels of competitiveness (the case of "neck and neck" competition see Aghion *et al.* 1997, 2001a; and Boone, 2000b).

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Chapter 4

Firm Dynamics, Productivity and Policy Settings

Abstract. *This last chapter moves one step further in the examination of the policy determinants of economic growth by exploiting a new firm-level database for ten OECD countries. It shows that the contribution to productivity growth from firm dynamic processes should not be overlooked, most notably in high-tech industries where new firms tend to boost overall productivity. There is evidence that burdensome regulations on entrepreneurial activity as well as high costs of adjusting the workforce negatively affect the entry of new small firms. Overall, there are a number of different features of entrant and exiting firms across countries. In particular, in the United States entrant firms tend to be smaller and with lower than average productivity, but those which survive the initial years expand rapidly. By contrast, firms tend to enter with a relatively higher size and productivity in Europe, but subsequently do not expand significantly. These findings tend to support the hypothesis of greater market experimentation in the United States, compared to many continental European countries, which in turn is likely to be the result of differences in regulatory settings across the Atlantic.*

Introduction

Chapter 3 focused on industry-level productivity and innovation and their dependence on policy and regulatory settings in the product and labour markets. This chapter makes a further step into the analysis of the micro-determinants of economic growth, by focussing on the contribution of reallocation of resources within narrowly-defined industries, resulting from the expansion of more productive firms and the entry of new firms, as well as the exit of obsolete ones. This aspect of reallocation may vary greatly across countries and has often been considered as a sign of economic dynamism. In particular, it has been argued that overall growth is usually associated with new entrants who displace obsolescent firms, and that this "creative destruction" contributes to overall technological progress, as new firms may better harness new technologies (Box 4.1). Moreover, by increasing competitive pressures, (the threat of) new entries may indirectly stimulate technological progress, even when productivity growth apparently takes place within incumbent firms.

The main task of this chapter is threefold. First it assesses the contribution of firm dynamics to industry-level productivity growth (Section 4.1). As such, it is the first attempt in the micro-economic literature to study the role of firm dynamics and its main characteristics for a relatively large set of countries and, more importantly, on the basis of harmonised data. Since firm dynamics seems to play an important role as a driver of productivity, the chapter then characterises this process in different industries and countries (Section 4.2). This evidence allows testing of some of the stylised facts presented in previous papers (*e.g.* Geroski 1995, Caves 1998) which were generally formulated with reference to very few countries. The analysis attempts to control for the sectoral composition of the economy, so as to isolate cross-country differences that may be related to differences in institutional and regulatory settings. Section 4.3 looks at the evolution of firms after market entry. The final task of the chapter is to further develop the analysis of policy influences on long-term growth (Section 4.4). This is done by assessing whether some of the regulatory settings in product and labour markets discussed in the previous chapter (with reference to overall industry MFP) also influence firm dynamics. In turn, this analysis sheds further light on one particular channel through which regulations may affect aggregate performance, namely *via* their negative impact on entry rates.

Box 4.1. "Creative Destruction", firm dynamics and economic growth

In the recent past, micro-evidence has accumulated to suggest a wide heterogeneity of firms' behaviour in most markets.[1] The distribution of output, employment, investment and productivity across firms and establishments varies widely; even in expanding industries, many firms experience substantial decline, and in contracting industries it is not uncommon to find rapidly expanding units. Likewise, business-cycle upturns and downturns do not necessarily involve a synchronised movement of all, or even most, firms or establishments.

There are a number of possible explanations for this. Heterogeneity may, for instance, reflect certain product market conditions, *e.g.* product differentiation. At the same time, and arguably more importantly, heterogeneity may be associated with a continual shift in the composition of the population of firms through entry, exit, expansion and contraction. This process of "creative destruction" (a notion usually ascribed to Joseph Schumpeter) may be important in developing and creating new processes, products and markets and, hence, in fostering overall economic growth.[2]

Various explanations have been formulated to describe the Schumpeterian process of "creative destruction". One group of explanations focuses on the learning process (either active or passive) of firms. Uncertainty about market conditions and profitability may, indeed, lead firms to make different choices concerning technologies, goods and production facilities. In the *passive learning* approach (Jovanovic, 1982) a firm enters a market without knowing its given potential profitability *ex ante*. Only after entry does the firm start to learn about its own profitability, based on information from realised profits. By continually updating such learning, the firm decides to expand, contract or exit. One of the main implications of this model is that smaller and younger firms should have higher and more variable growth rates. In the *active learning* approach (Ericson and Pakes, 1995) a firm actively explores its economic environment and invests in order to enhance its profitability under competitive pressure from both within and outside the industry. Its profitability changes over time in response to the outcomes of the firm's own investment and those of other actors in the same market. The firm grows if successful and shrinks or exits if not. In any event, because of the inherent uncertainty in experimentation, even an entrant who is very successful, *ex post*, will typically begin small. The accumulation of experience and assets, in turn, strengthens survivors and lowers the likelihood of failure.

Box 4.1. "Creative Destruction", firm dynamics and economic growth *(cont.)*

A second group of explanations of the "creative-destruction" process stresses that new technology is often embodied in new capital, which requires a costly retooling process in existing plants adopting these technologies, as well as in some cases changing work practices.[3] Insofar as new firms do not have to go through this process, they may better harness new technologies. Hence, overall growth will be associated with new entrants who displace obsolete establishments.[4] In this case, the process of "creative destruction" also contributes to the observed heterogeneity in firms' performance, to the extent that some sunk costs impede the exit of oldest and least productive firms.

1. For a survey of recent empirical studies see Caves (1998) and Bartelsman and Doms (2000).
2. For analyses of "creative destruction" and its links with economic growth, see, amongst others, Aghion and Howitt (1992) and Caballero and Hammour (1994, 1996). Foster, Haltiwanger and Krizan (1998), Caves (1998) and Bartelsman and Doms (2000) offer further discussion on this literature.
3. For such vintage models of technological change, see for instance Cooley *et al.* (1997), and Jensen *et al.* (2001).
4. Models emphasising such a strong link between economic growth and the process of entry and exit include Caballero and Hammour (1994), Mortensen and Pissarides (1994) and Campbell (1997).

4.1. What lies behind within-industry productivity growth? Reallocation of resources *versus* within-firm growth

Chapter 3 has shown that overall productivity gains result predominantly from an intra-industry effect. The following natural step is, therefore, to look inside different industries to assess how the reallocation of resources among incumbents, as well as between entrants and exiters, shapes industry productivity growth. This process of "creative destruction", whereby new entrants displace obsolescent firms, may be especially important in the current period of diffusion of a new general purpose technology, such as ICT.

Methodological issues

The analysis presented in this Section offers a consistent international comparison of firm dynamics and its contribution to aggregate productivity, through the use of specially-constructed firm-level data (Box 4.2) for ten OECD countries (United States, Germany, France, Italy, United Kingdom, Canada, Denmark, Finland, Netherlands and Portugal). These harmonised data are used below to assess the role of entry and exit and reallocation amongst existing firms in total productivity growth. Notwithstanding the efforts made to minimise inconsistencies along different dimensions (*e.g.* sectoral

Box 4.2. **Building up a consistent international dataset: the OECD firm-level study**[1]

Sources of data

Available data at the firm level are usually compiled for fiscal and other purposes and, unlike macroeconomic data, there are few internationally agreed definitions and sources, although harmonisation has improved over the years (see Annex 3 for more details on the OECD firm-level project).

The analysis of firm entry and exit is based on business registers (Canada, Denmark, France, Finland, Netherlands, the United Kingdom and the United States) or social security databases (Germany and Italy). Data for Portugal are drawn from an employee-based register containing information on both establishments and firms. These databases allow firms to be tracked over time because addition or removal of some of them from the registers (at least in principle) reflects their actual entry and exit. The decomposition of aggregate productivity growth requires (in this chapter) a wider set of variables and is based on production survey data, in combination with business registers.

Definition of key concepts

The entry rate is defined as the number of new firms divided by the total number of incumbent and entrant firms in a given year; the *exit rate* is defined as the number of firms exiting the market in a given year divided by the population of origin, i.e. the incumbents in the previous year.

Labour productivity growth is defined as the difference between the rate of growth of output and that of employment[2] and, whenever possible, controls for material inputs.

Multi-factor productivity growth is the change in gross output less the share weighted changes in three different inputs:[3] labour, measured by the number of employed persons; capital, based on the perpetual inventory method; and, material inputs. Real values for output are calculated by applying 2-4 digit industry deflators.

Comparability issues

Two prominent aspects of the data have to be borne in mind when comparing firm-level data across countries:[4]

- *Unit of observation*: the data used in this study refer to "firms' rather than "establishments". Firm-based data are likely to more closely

Box 4.2. **Building up a consistent international dataset: the OECD firm-level study[1]** *(cont.)*

represent entities that are responsible for key aspects of decision-making, compared with plant-level data. Nevertheless, business registers may define firms at different points in ownership structures; for example, some registers consider firms that are effectively controlled by a "parent" firm as separate units, whilst others record only the parent company.[5]

- *Size threshold*: while some registers include even single-person businesses, others omit firms smaller than a certain size, usually in terms of the number of employees but sometimes in terms of other measures, such as sales (as is the case in the data for France and Italy). Data used in this book exclude single-person businesses. However, because smaller firms tend to have more volatile firm dynamics, remaining differences in the threshold across different country datasets should be taken into account in the international comparison.[6]

1. A subset of the firm-level data is available on the OECD's website at: *www.oecd.org/EN/document/0,,EN-document-492-nodirectorate-no-1-35177-3,00.html*
2. Available data do not allow the control for changes in hours worked, nor do they distinguish between part- and full-time employment.
3. Changes are calculated at the firm level but income shares refer to the industry average in order to minimise measurement errors.
4. For more detail on the comparability of the firm-level data, see Bartelsman *et al.*, (2002).
5. This may not be a major shortcoming in practice, judging from US data. Indeed, when repeating the decomposition of productivity growth for the United States on the basis of establishment instead of firm data, the results remain largely unchanged.
6. This may also not be a major shortfall in practice: a sensitivity analysis on Finnish data, where cut-off points were set at 5 and 20 employees, reveals broadly similar results.

breakdown, time horizon, definition of entry and exit, etc.), some remaining differences have to be taken into account when interpreting the results.

At the industry level, productivity growth is the result of different combinations of: *i)* productivity gains within existing firms; *ii)* increases in the market-share of high-productivity firms; and *iii)* the entry of new firms that displace less productive ones. Productivity growth within firms depends on changes in the efficiency and intensity with which inputs are used in production. Thus, this source of aggregate productivity growth is associated with the process of technological progress. Shifts in market shares between high and low productive units also affect aggregate productivity trends, as does the reallocation of resources across entering and exiting firms. The overall contribution of reallocation to productivity growth is generally identified with a competitive process taking place in the market, although it

may also reflect changes in demand conditions and, as argued above, may also be an aspect of technological progress.

It should be stressed that this simple taxonomy hides important interactions. The entry of highly productive firms in a given market may stimulate productivity-enhancing investment by incumbents trying to preserve their market shares. Moreover, firms experiencing higher than average productivity growth are likely to gain market shares if their improvement is the result of a successful upsizing, while they will lose market shares if their improvement was driven by a process of restructuring associated with downsizing.

There are a number of ways in which aggregate productivity can be decomposed into a within-firm component and different components due to the reallocation of resources across firms. The decompositions reported below refer to the approach developed by Griliches and Regev (1995) (see Box 4.3,

Box 4.3. **The decomposition of productivity growth**

The approach used to decompose productivity growth is from Griliches and Regev (1995): in this decomposition, each term is weighted by the average (over the time interval considered) market shares, as follows:

$$\begin{aligned}\Delta P_t \;=\; & \sum_{Continuers} \overline{\theta}_i \Delta p_{it} + \sum_{Continuers} \Delta\theta_{it}(\overline{p}_i - \overline{P}) \\ & + \sum_{Entries} \theta_{it}(p_{it} - \overline{P}) - \sum_{Exits} \theta_{it-k}(p_{it-k} - \overline{P})\end{aligned}$$

where Δ means changes over the k-years' interval between the first year (t – k) and the last year (t); θ_{it} is the share of firm *i* in the given industry at time t (it could be expressed in terms of output or employment); p_i is the productivity of firm *i* and P is the aggregate (*i.e.* weighted average) productivity level of the industry.[1] A bar over a variable indicates the averaging of the variable over the first year (t – k) and the last year (t). In the equation above, the first term is the within component; the second is the between component, while the third and fourth are the entry and exit components, respectively.

Such decomposition will give different results depending on the time horizon considered. Concretely, the decompositions reported in Figure 4.1 concern productivity growth over five-year periods, but it should be kept in mind that their interpretation is not entirely clear-cut. In particular, if market shares change significantly over the five-year interval, the "within" effect in fact also includes a reallocation effect.

1. The shares are based on employment in the decomposition of labour productivity and on output in the decomposition of multi-factor productivity.

Annex 3 and Scarpetta *et al.* (2002) for further details). It is applied to both labour and MFP, based on 5-year rolling windows for all periods and industries for which data are available.

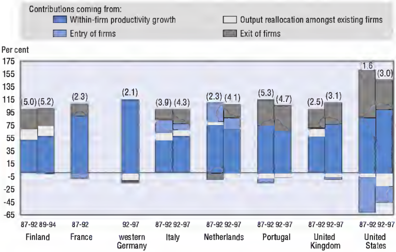
The decomposition of labour productivity: within-firm growth plays a dominant role

Figure 4.1 presents the decomposition of labour productivity growth in manufacturing sectors for two five-year intervals, 1987-92 and 1992-97. It suggests that productivity within each firm accounted for the bulk of overall labour productivity growth. The impact on productivity via the reallocation of output across existing enterprises (the "between" effect) varies significantly across countries and time, but it is typically small.[1] Finally, the net contribution to overall labour productivity growth of the entry and exit of firms (net entry) is positive in most countries (with the exception of western Germany over the 1990s), accounting for between 20 per cent and 40 per cent of total productivity growth.

In countries where a sufficiently long time series is available, evidence suggests that year-to-year changes in the within-firm component are the main drivers of fluctuations in aggregate productivity growth; the *between* and

Figure 4.1. **Decomposition of labour productivity growth in manufacturing[1]**

Percentage share of total annual productivity growth of each component[2]



Note: Figures in brackets are overall productivity growth rates (annual percentage change).
1. See Box 4.3 for details.
2. Components may not add up to 100 because of rounding.
Source: OECD.

net entry components show only modest fluctuations (see Annex 3 for more details). Consequently, in years of expansion (the second half of the 1980s in most countries), within-firm growth makes a stronger contribution to overall productivity growth, whereas in slowdowns (the early 1990s) the contribution of between and net entry components increase in relative importance,[2] particularly because of the exit of low-productive units.

The entry of new firms has variable effects on overall productivity growth. On the whole, data for European countries[3] show that new firms typically make a positive contribution to overall productivity growth (see Table 4.1), although the effect is generally of small magnitude. By contrast, entries make a negative contribution in the United States for most industries. Instead a strong contribution to productivity growth in the United States comes from the exit of low-productivity firms. This finding is consistent with further evidence that is presented below, indicating a somewhat different nature of the entry (and exit) process in the United States compared with most other countries.

Table 4.1. **Analysis of productivity components across industries of manufacturing and services**

Panel A. Proportions of positive contributions to labour productivity growth across manufacturing industries[1]

	Total number of observations (industry * year)	Entry contribution %	Exit contribution %	Between component %
Finland	420	57	93	62
France	126	47	81	40
Italy	348	84	89	85
Netherlands	344	76	77	51
Portugal	211	63	91	49
United Kingdom	392	62	92	45
United States	58	10	98	31

Panel B. Proportions of positive contributions to labour productivity growth across business services[1]

	Total number of observations (industry * year)	Entry contribution %	Exit contribution %	Between component %
Finland	24	50	79	46
western Germany	18	56	71	50
Italy	227	30	54	29
Portugal	191	39	66	43

Note. These calculations are based on all available data with manufacturing and business services. The time periods considered vary considerably across countries.

1. Number of cases in which the different components made a positive contribution to labour productivity growth (in % of total number of cases).

Source: OECD.

It should be noted that by construction, the contribution of entering firms is greater the longer the horizon considered.[4] Moreover, if new entrants undergo a significant process of learning and selection, the time horizon is likely to further affect the comparison between entering and other firms. For example, US studies focusing on long time horizons generally found a significantly higher contribution of entry to aggregate productivity growth than those using short time periods, as in this chapter.[5]

Although the driving forces of aggregate labour productivity growth differ across countries, a few common patterns can be identified (for details, see Scarpetta *et al.*, 2002). In particular, in the industries more closely related to ICT, the entry component makes a stronger contribution to labour productivity growth than on average.[6] This is particularly the case in the United States, where the contribution from entrants in ICT sectors to labour productivity growth is strongly positive, in contrast to the negative effect observed in most other manufacturing industries. This result suggests an important role for new firms in an area characterised by a strong wave of technological change. The opposite seems to be the case in more mature industries, where a more significant contribution comes from either within-firm growth or the exit of, presumably, obsolete firms.

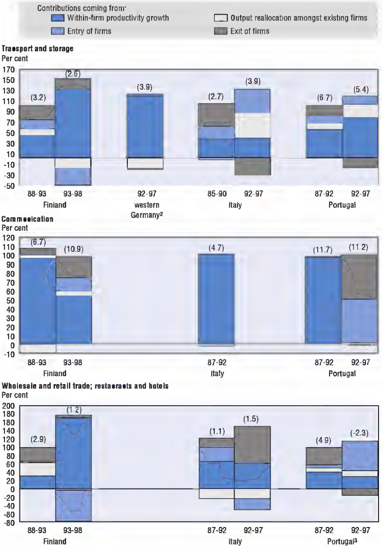
The decomposition of labour productivity growth in service sectors gives far more varied results than for manufacturing, no doubt because of the difficulties in properly measuring output in this area of the economy (see Annex 1). But, in some broad sectors, *transport and storage*, *communication* and *wholesale and retail trade*, the results are qualitatively in line with those for manufacturing (Figure 4.2). The within-firm component is generally larger than that related to net entry and reallocation across existing firms, although in *transport and storage*, as well as in *communication*, entering firms seem generally to have a higher than average productivity, raising overall aggregate growth.

The decomposition of multi-factor productivity: a stronger effect from reallocation

Figure 4.3 presents the decomposition of MFP growth in the manufacturing sector of six countries. It should be stressed at the outset that MFP estimates are less robust than those of labour productivity, because of the difficulty of measuring the stock of capital at the firm level. Bearing this caveat in mind, the decomposition of MFP growth suggests a somewhat different picture from that shown with respect to labour productivity. Thus, although it still drives overall fluctuations, the within-firm component provides a comparatively smaller contribution to overall MFP growth. At the same time, the reallocation of resources across incumbents (*i.e.* the between effect) plays a somewhat stronger role. More important, a strong contribution to MFP

Figure 4.2. **Decomposition of labour productivity growth in selected service sectors**

Percentage share of total annual productivity growth of each component[1]

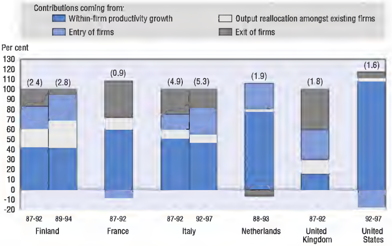


Note: Figures in brackets are overall productivity growth rates (annual percentage change).
1. Components may not add up to 100 because of rounding.
2. Transport, storage and communication.
3. Wholesale and retail trade.

Source: OECD.

Figure 4.3. **Decomposition of multi-factor productivity growth in manufacturing**

Percentage share of total annual productivity growth of each component[1]



Note: Figures in brackets are overall productivity growth rates (annual percentage change).
1. Components may not add up to 100 because of rounding.
Source: OECD.

growth generally comes from net entry. Indeed, the (limited) information available suggests that the entry of new highly productive firms has made a marked impact on aggregate trends in the more recent past.

Combining information on labour and MFP decompositions with the evidence presented in Chapter 1,[7] it could be tentatively hypothesised that in a number countries (including some European economies), incumbent firms were able to increase labour productivity mainly by substituting capital for labour (capital deepening) or by exiting the market altogether, but not necessarily by markedly improving overall efficiency in production processes. By contrast, new firms entered the market with the "appropriate" combination of factor inputs and new technologies, thus leading to faster growth of MFP.

Additional evidence from the productivity decomposition

The productivity decomposition discussed above is a simple accounting exercise that does not consider possible interactions between its different components. In this regard:

- There is a positive correlation between the entry rate in a given industry and the average labour productivity levels; that is to say, high-productivity

industries are associated with relatively high entry rates. This may reflect new firms putting competitive pressure on incumbents, or highly productive industries attracting more entrants.

- Within each country, high-productivity industries tend to have a wider dispersion of productivity levels than other industries. Specifically, while most industries, regardless of their aggregate level of productivity, have a number of relatively low productive firms, high overall productivity in some industries is largely driven by the presence of "exceptional" performers that lengthen the right-hand tail of the distribution of industry productivity.

4.2. The entry and exit of firms

Since the entry and exit of firms makes a significant – albeit not dominant – contribution to aggregate productivity growth, it is of interest to see how frequently new firms are created and how often existing units close down. In fact, a large number of firms enter and exit most markets every year (Panel A of Figure 4.4). Data covering the first part of the 1990s show firm turnover rates (entry plus exit rates) to be around 20 per cent in the business sector of most countries (Panel B of Figure 4.4): *i.e.* a fifth of firms are either recent entrants, or will close down within the year.

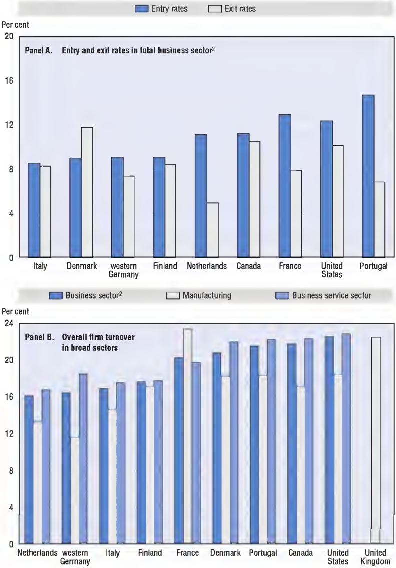
The industry dimension also makes it possible to compare entry and exit rates and characterise turnover. If entries were driven by relatively high profits in a given industry, and exits occurred primarily in sectors with relatively low profits, there would be a negative cross-sectional correlation between entry and exit rates. However, confirming previous evidence,[8] entry and exit rates are generally highly correlated across industries in OECD countries (this is particularly so when the rates are weighted by employment) (Table 4.2). This finding suggests a process of "creative destruction", whereby a large number of new firms displace continuously a large number of obsolete firms.

The variability of turnover rates for the same industry across countries is comparable in magnitude to that across industries in each country. In other words, the observed variability of turnover across countries can be explained both by industry-specific and country-specific effects.

It is possible to assess these country-specific effects by estimating entry rates for each country once differences in the sectoral composition are taken into account, by means of (fixed-effects) panel regression.[9] Overall, Figure 4.5 suggests a similar degree of "firm churning" in Europe and the United States: with the exception of western Germany and Italy, all countries have higher entry rates than the United States, but differences are small and would, in fact, be even smaller if the different size structure of firms across countries were taken into account.[10]

Figure 4.4. **High firm turnover rates in OECD countries**

Entry and exit rates,[1] annual average, 1989-1994



1. The entry rate is the ratio of entering firms to the total population. The exit rate is the ratio of exiting firms to the population of origin. Turnover rates are the sum of entry and exit rates.
2. Total economy minus agriculture and community services.

Source: OECD.

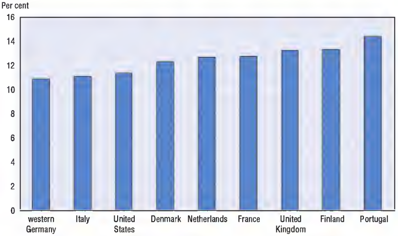
Table 4.2. **Strong correlation between entry and exit rates,[1] 1989-1994**

	Total number of observations (industry * year)	Correlation	T-statistic	Weighted by employment	
				Correlation	T-statistic
United States	47	0.67	6.02	0.86	11.25
western Germany	22	0.73	4.72	0.87	8.03
France	41	–0.21	–1.36	0.73	6.74
Italy	43	–0.22	–1.47	0.53	3.97
United Kingdom	26	0.68	4.95	0.21	1.14
Denmark	23	0.80	6.17	0.75	5.16
Finland	44	0.15	0.99	0.38	2.69
Netherlands	49	0.44	3.36	..	..
Portugal	41	0.60	4.91	0.64	5.47

1. Correlations of average industry entry rates and average industry exit rates over the period 1989-1994.
Source: OECD.

Regarding industry-specific factors, a general finding (which does not, however, apply to all countries) is that turnover rates are somewhat higher in the service sector than in manufacturing (see Panel B in Figure 4.4).[11] At a more detailed level, once country and size effects are controlled for, high technology manufacturing industries and some business-service industries,

Figure 4.5. **Estimated entry rates with control for industry composition[1]**

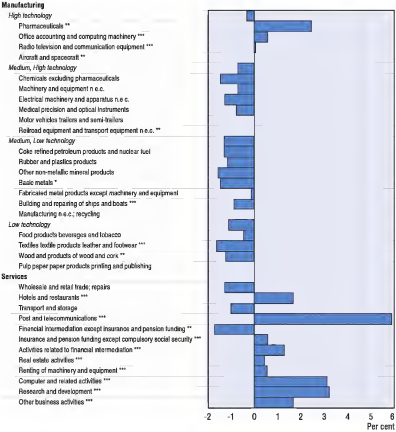


1. Figures reported are the country-fixed effects in an entry equation that controls for industry and time fixed effects. See Table 4.5.
Source: OECD.

in particular those related to ICT, have higher entry rates than average (Figure 4.6).[12] This evidence ties up with earlier discussion on the role of entry in productivity growth in high-tech industries, and lends some support to the vintage models of technological change, whereby rapid technological changes are associated with a number of new innovative units replacing a number of outpaced ones.

Figure 4.6. **Significant differences in entry rates across industries**

Estimated industry[1] entry rates relative to the total business sector



* indicates signifiance at 1%; ** at 5% and *** at 10%.

1. Figures reported are the industry fixed-effects in an entry equation that includes country, size and time fixed effects. See Table 4.5.

Source: OECD.

Some studies have argued that variation in firm entry rates across industries partly relates to differences in product cycles. Some evidence suggests that after commercial introduction of a specific new product there is an initial phase of rapid firm entry, which is followed by a levelling off and a contraction in the number of firms.[13] For example, the observation of "waves" of entry at different points in time across industries may reflect initial phases in the product cycle. In this context, the high entry rates observed in the ICT-related industries may reflect the fact that ICT products are still in a relatively early phase of their cycle. There is some indirect[14] support for this view: the correlation between ranks of industries (according to their turnover rate) at different points in time is not very high and tends to decline as yearly observations are further apart (Table 4.3). Hence, high entry industries at a point in time are not necessarily at the top of the entry ranking of industries ten or even five years later. This result could indicate that competitive forces in each market change significantly over time because of the maturing of the market in which firms operate.

Table 4.3. **Differences in entry rates across industries do not persist over time**

Rank correlation of industry entry rates between different years[1]

	Interval	Based on firm entry rates	Based on employment-weighted entry rates
United States	1990-1995	0.86	0.79
western Germany	1990-1998	0.94	0.60
	1993-1998	0.88	0.26
France	1991-1995	0.59	0.59
Italy	1988-1993	0.73	0.58
Denmark	1984-1994	0.82	0.56
	1989-1994	0.77	0.02
Finland	1990-1997	0.27	–0.02
	1993-1997	0.20	–0.02
Netherlands	1994-1997	0.59	0.31
Portugal	1985-1994	0.55	0.36
	1989-1994	0.75	0.30

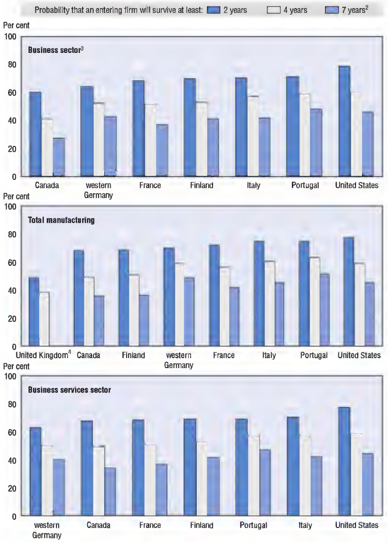
1. Spearman rank correlation.
Source: OECD.

4.3. Which firms survive and which expand?

The high correlation between entry and exit across industries may be the result of new firms displacing old obsolete units, as well as high failure rates amongst newcomers in the first years of their life. Looking at survival rates, i.e. the probability that new firms will live beyond a given age (Figure 4.7), can

Figure 4.7. **Strong market selection amongst new entrants**

Firm survivor rates at different lifetimes[1]



1. Figures refer to average survivor rates estimated for different cohorts of firms that entered the market from the late 1980s to the 1990s.
2. After 6 years for the United Kingdom.
3. Total economy minus agriculture and community services.
4. Data for the United Kingdom refer to cohorts of firms that entered the market in the 1985-1990 period.

Source: OECD, and Baldwin *et al.* (2000) for Canada.

help assess this. The survival probability for cohorts of firms that entered their respective market in the late 1980s declines steeply in their initial phases of life: only about 60-70 per cent of entering firms survive the first two years. Having overcome the initial years, the prospects of firms improve in the subsequent period: those that remain in business after the first two years have a 50 to 80 per cent chance of surviving for five more years. Nevertheless, on average, only about 40 to 50 per cent of firms entering in a given year survive beyond the seventh year.

As in the case of firm turnover, differences in the industry mix across countries could partly cloud the international comparison of survivor rates. After controlling for sectoral composition,[15] survival rates on a four-year horizon appear to be lower in the United States and – even more so – in the United Kingdom than in continental European countries. It is important to note that a low survival rate is not necessarily a cause of concern. Entry by new firms may be seen as a process of experimentation and it is in the nature of this process that the failure rate will be high. This is particularly so if new entry leads incumbent firms to increase their efficiency and profitability, as seems to be the case in the United States (see below).

There is substantial variation in survival rates at different life spans across manufacturing industries and the entire business sector. Overall, the variance of "infant mortality" (*i.e.* failure within the first years) across industries is of the same order of magnitude as the variance of entry rates across industries (Table 4.4).[16] Furthermore, these industry differences in initial failure are also reflected in the variability of long-term survival rates

Table 4.4. **Variability of entry and hazard rates across industries, 1989-1994**

Non-agricultural business sector, standard deviations of entry and hazard rates across industries

	Standard deviation of:							
	Entry rates	Hazard rates						
		At duration:						
		1	2	3	4	5	6	7
United States	4.52	1.96	2.78	2.34	3.25	3.45	2.76	2.26
western Germany	2.77	3.98	3 54	3.53	2.57	3.51	2.08	3.29
France	5.29	2.68	3.14	4.12	3.18	2.91	3.52	7.8
Italy	4.98	2.99	2 23	3.33	4.48	2.19	2.59	4.15
United Kingdom	7.14	3.49	3.22	4.33	2.94	2.84	4.64	. .
Finland	3.72	6.97	4.55	4.36	4.72	4.16	7.52	11.15
Portugal	6.37	8.72	8 95	9.63	4.07	4.39	6.9	8.27

Source: OECD.

(*i.e.* five-seven years of age), which remains substantial. To the extent that cross-industry variability may be taken as an indicator of the different market barriers that affect young firms, the evidence reported in Table 4.4 may indicate a degree of commonality between industry characteristics that affect barriers to entry and those that condition firm survival.[17]

The process of entry and exit of firms involves a proportionally low number of workers, *i.e.* employment turnover related to the process of entry and exit is lower than firm turnover, because entrants and exiting firms are generally smaller than incumbents (Figure 4.8, and Box 4.4). The particularly small size of entrants in the United States, Canada and Germany reflects either the large size of incumbents (*e.g.* the United States, see Bartelsman *et al.*, 2002) or the small average size of entrants compared with that in most other countries (Germany and Canada, see Figure 4.8). In other words, entrant firms are further away from the average size in these countries. At the same time, there is general tendency for failure in the early years of activity to be concentrated amongst small units, while surviving firms are not only larger but also tend to grow rapidly. Thus, in most countries the size of exiting firms is broadly similar to that of entering firms. Moreover, the average size of surviving firms increases rapidly to approach that of incumbents in the market in which they operate. However, the expansion of surviving firms is notably higher in the United States than in Europe (Figure 4.9).[18]

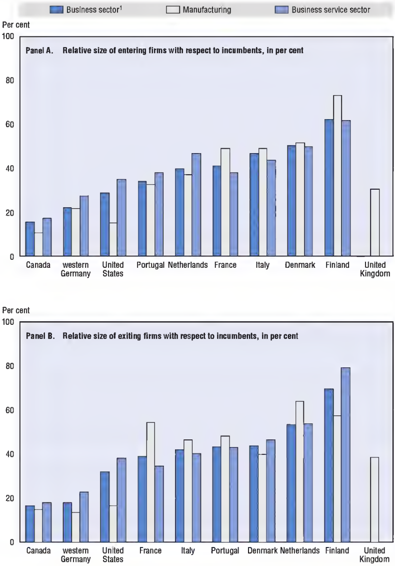
The marked difference in post-entry behaviour of firms in the United States, compared with European countries, is partially due to the larger gap between the size at entry and the average firm size of incumbents, *i.e.* there is a greater scope for expansion amongst young ventures in the US markets than in Europe. In turn, the smaller relative size of entrants can be taken to indicate a greater degree of experimentation, with firms starting small and, if successful, expanding rapidly to approach the minimum efficient scale.[19] Firm characteristics at entry are influenced by market conditions (concentration, product diversification, advertising costs, etc.) but may also depend on regulations and institutions affecting start-up costs and efficiency-enhancing decisions by existing firms, as discussed below.

4.4. Regulations, institutions and firm entry: empirical analysis

This section aims at exploring possible policy and institutional influences on the observed patterns of firm entry documented earlier. Its main objective is to assess whether policy factors help explain the observed differences in entry rates across countries and industries, by linking together the firm-level dataset described above with the OECD indicators of regulations and institutional settings already used in Chapter 3 above. The limits inherent to this empirical methodology are very similar to – and arguably more significant

Figure 4.8. **Entrant and exiting firms are relatively small**

Firm size based on the number of employees per firm, 1989-1994



1. Total economy minus agriculture and community services.

Source: OECD.

Box 4.4. **The size of firms across sectors and countries**

Firm-level data indicate marked differences in the average size of firms across the OECD countries considered in this chapter (see Bartelsman *et al.*, 2002 for more details). These include:

- In all countries, the distribution of firms is highly skewed towards small units (fewer than 20 employees), although the average size of firms, calculated as total employment over total number of firms, ranges from less than 15 employees in Italy, Canada, Denmark and Finland to more than 30 in France (see table below). These data refer to incumbents and exclude firms without employees. The observed cross-country differences are only marginally affected by different size thresholds in the datasets, with the likely exception of France, where firms below a certain turnover are excluded.
- Small firms account for a larger share of employment in services than in manufacturing, arguably because technological factors and economies of scale play a more important role in the latter. In all but one country (France), the average firm size is two to three times larger in manufacturing than in services. In addition, high-tech industries tend to have a smaller than average proportion of small firms, with a particularly strong effect in Italy, the Netherlands and, especially, Finland.
- The analysis in Bartelsman *et al.* (2002) suggests that the differences in average firm size between countries reflect both *industry specialisation* and *within-industry* variations in size. Two countries show a low cross-industry deviation in firm size (Denmark and Canada), with the Netherlands, Germany, Finland and Italy in the intermediate range, and the remainder with a more dispersed size of firms across industries. Moreover, there is a positive association between the overall size of a country (total employment) and the within-industry dispersion of firm size, *i.e.* the bigger the country the greater the variability of firm size within each industry.

Average size of firms

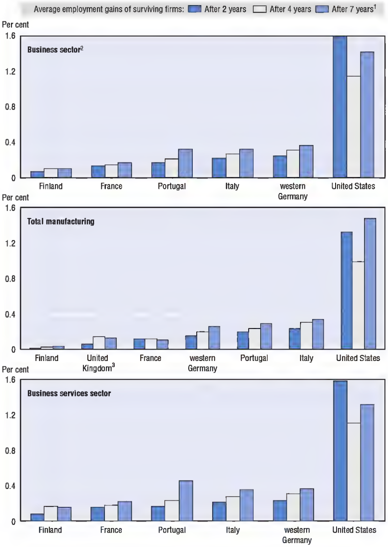
Number of employees per firm, 1989-1994

	Total economy	Non-agricultural business sector[1]	Manufacturing	Business services
United States	26	26	80	26
western Germany	17	18	39	12
France	34	33	32	36
Italy	11	10	15	7
United Kingdom	..	..	41	..
Canada	13	15	41	14
Denmark	13	15	30	13
Finland	13	13	28	10
Netherlands	15	14	31	11
Portugal	17	18	31	12

1. Total economy excluding agriculture and community services.
Source: OECD.

Figure 4.9. **Different post-entry growth patterns across the OECD countries**

Net employment gains among surviving firms as a ratio of initial employment, 1990s



1. After 6 years for the United Kingdom.
2. Total economy minus agriculture and community services.
3. Data for the United Kingdom refer to cohorts of firms that entered the market in the 1985-1990 period.

Source: OECD.

than – those mentioned in Chapter 3: most importantly, the decision of a firm to enter the market depends on a number of additional factors that are not controlled for. In addition, the country coverage is relatively narrow. Therefore, the evidence presented in this section and its policy implications should be viewed as tentative.

The entry equation is based on a theoretical model in which entry depends on the expected (post-entry) profits, defined net of the costs of entry.[20] In the estimates, the actual proxies for these two variables are the smoothed growth rate of industry value-added for market profitability, and the smoothed capital intensity (*i.e.* capital stock divided by value added) for entry costs: high capital intensity implies a large share of fixed costs and thus raises entry costs, *ceteris paribus*. In this framework, indicators of the stringency of regulations can also influence entrepreneurship. The analysis also accounts for the size effect on firm dynamics (using five size classes, from *fewer than* 20 employees to *more than* 500 employees), and allows testing whether incentives and disincentives to entry differ according to the size of firms.

Table 4.5 presents the baseline entry equation, which neither controls for the impact of net expected profits nor for the effect of policy and institutional factors. The results only shed some light on possible country and size effects on entry rates, once control for sector composition is taken into account. Equation A includes year dummies to control for specific time effects, while Equation B uses a country-specific measure of the business cycle. Equation C includes both, in order to test for common and country-specific time patterns of entry. Since the inclusion of the business cycle variable in a specification with time dummies does not significantly affect the results, it is not included in the other specifications. Equation D controls for the presence of outliers in the data and Equation E replicates it without size dummies to identify the overall country-specific effects, including those related to differences in the size structure of firms. As noted in Section 4.2, the estimated country differences in entry rates are generally statistically significant, but not very large, once control is made for the industry composition of the economy. Moreover, with the exception of Germany and Italy, entry rates are higher in the United States (the reference country in all regressions) than in other countries, *ceteris paribus*. The results also suggest a non-linear relationship between the entry rates and size: small firms (with fewer than 20 employees) have significantly higher entry rates than the reference group (20-49), while larger firms (50 and more) have only marginally lower entry rates with respect to the reference group.

Table 4.6 moves one step further in the analysis to include proxies for profitability and entry barriers that could partially account for the country (and industry) fixed effects. The analysis starts with the most parsimonious

Table 4.5. Entry rate regressions: baseline specification[1]

Dependent variable = entry rate

	A	B	C	D	E
	With year dummies	With gap variable for the cycle[2]	With both year dummies and variable for cycle	… also with control for outliers	Without size effects
Constant	3.40***	2.72***	3.36***	3.79***	5.26***
	(0.55)	*(0.24)*	*(0.55)*	*(0.42)*	*(0.64)*
Country:					
western Germany	–1.27***	–1.37***	–1.26***	–1.38***	–0.56***
	(0.18)	*(0.18)*	*(0.18)*	*(0.14)*	*(0.21)*
France	1.39***	1.40***	1.39***	1.09***	1.35***
	(0.15)	*(0.15)*	*(0.15)*	*(0.12)*	*(0.18)*
Italy	–0.54***	–0.15	–0.54***	–0.65***	–0.34*
	(0.16)	*(0.15)*	*(0.16)*	*(0.12)*	*(0.19)*
United Kingdom	1.99***	2.17***	2.02***	1.58***	1.84***
	(0.19)	*(0.18)*	*(0.19)*	*(0.14)*	*(0.22)*
Denmark	0.89***	1.22***	0.86***	0.74***	0.89***
	(0.18)	*(0.16)*	*(0.18)*	*(0.14)*	*(0.22)*
Finland	0.53***	0.75***	0.38*	0.12	1.91***
	(0.16)	*(0.19)*	*(0.20)*	*(0.15)*	*(0.24)*
Netherlands	0.46***	0.58***	0.47***	0.19*	1.29***
	(0.14)	*(0.14)*	*(0.14)*	*(0.11)*	*(0.16)*
Portugal	1.79***	1.89***	1.79***	1.26***	3.03***
	(0.15)	*(0.14)*	*(0.15)*	*(0.12)*	*(0.18)*
Size:					
less than 20	7.38***	7.39***	7.38***	6.97***	
	(0.10)	*(0.10)*	*(0.10)*	*(0.08)*	
50-99	–0.40***	–0.40***	–0.40***	–0.45***	
	(0.11)	*(0.11)*	*(0.11)*	*(0.09)*	
100-499	–0.32***	–0.32***	–0.32***	–0.48***	
	(0.11)	*(0.12)*	*(0.11)*	*(0.09)*	
500 and more	0.001	–0.02	–0.004	–0.59***	
	(0.17)	*(0.17)*	*(0.17)*	*(0.13)*	

Note: See Annex 3 for details on the definition of entry rates. Robust standard errors are in brackets. * : significant at 10% level; ** at 5% level; *** at 1% level.

1. The textile, footwear and leather products industry with 20-49 employees in the United States is the reference group in these equations.
2. Output gap from OECD *Economic Outlook*, No 70.

Source: OECD.

Table 4.6. **Entry rate regressions: the role of regulations and institutions**

	A	B	C	D	E	F	G	H
	2.86***	2.95***	3.05***	3.24***	3.28***	4.22***	4.30***	2.25**
	(0.40)	*(0.41)*	*(0.42)*	*(0.41)*	*(0.41)*	*(0.56)*	*(0.56)*	*(0.89)*
ΔlogVA	0.46	–3.49*	–2.55	–2.66	–2.54	–2.73	–2.98	–3.40*
	(1.82)	*(1.97)*	*(1.93)*	*(1.94)*	*(1.94)*	*(1.93)*	*(1.93)*	*(1.96)*
ΔlogVA (less than 20)		10.36***	11.21***	11.07***	11.07***	11.40***	11.96***	11.09***
		(2.69)	*(2.82)*	*(2.81)*	*(2.82)*	*(2.79)*	*(2.77)*	*(2.66)*
LogKY	–0.23*	–0.20	–0.24*	–0.27**	–0.28**	–0.31**	–0.34***	–0.29**
	(0.13)	*(0.13)*	*(0.12)*	*(0.12)*	*(0.12)*	*(0.12)*	*(0.12)*	*(0.13)*
PM regulations (PMR)			–0.15					
			(0.10)					
PM (administrative regulations)				–0.32***				
				(0.06)				
PM (admin. barriers to start up) * size (less than 20)						–0.70***		
						(0.19)		
PM (admin. barriers to start up) * size (20-49)						–0.60***		
						(0.14)		
PM (admin. barriers to start up) * size (50-99)						–0.25*		
						(0.13)		
PM (admin. barriers to start up) * size (100-499)						0.03		
						(0.10)		
PM (admin. barriers to start up) * size (500 and more)						0.47**		
						(0.24)		
PM (sector specific)					–1.64***			
					(0.38)			
PM (sector specific) * size (less than 20)							–5.33***	–6.35***
							(0.93)	*(1.05)*

Table 4.6. **Entry rate regressions: the role of regulations and institutions** *(cont.)*

	A	B	C	D	E	F	G	H
PM (sector specific) * size (20-49)							−3.95***	−2.70***
							(0.77)	*(0.96)*
PM (sector specific) * size (50-99)							−1.65**	−1.05
							(0.75)	*(0.93)*
PM (sector specific) * size (100-499)							0.83	2.53***
							(0.58)	*(0.94)*
PM (sector specific) * size (500 and more)							3.25**	−2.32
							(1.35)	*(1.94)*
EPL * size (less than 20)								0.23*
								(0.12)
EPL * size (20-49)								−0.28***
								(0.10)
EPL * size (50-99)								−0.13
								(0.10)
EPL * size (100-499)								0.07
								(0.34)
EPL * size (500 and more)								0.87***
								(0.20)
Number of observations	3197	3196	3196	3196	3196	3198	3198	3196
Country dummies	Yes	Yes	No	No	No	No	No	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: See Annex 3 for details on the definition of entry rates. Robust standard errors are in brackets. * : significant at 10 % level; ** at 5% level; *** at 1% level.
Source: OECD.

specification, then adds other explanatory variables, and ends with the most comprehensive equation (Equation H), offering the best statistical fit. The results are largely as expected:

- The growth rate of industry value-added has a positive impact on entry. There is also evidence of a significantly larger effect for small rather than other firms, so that a distinction is considered from Equation B onwards.
- Costs of entry, as proxied by capital intensity, appear to negatively affect entry rates (though at somewhat variable levels of significance).
- In most cases, the stringency of product market regulations also significantly lowers entries. Administrative regulations on entrepreneurial activities seem to be particularly detrimental to entry (column D). This negative effect is felt by small- and medium-sized firms, while on the contrary it is found to be positive for larger firms (column F). All these findings appear to be relatively robust to the choice of the PMR indicator (columns E and G).[21] The positive effect of regulation on the entry of large firms is puzzling, but it is likely to be influenced by the characteristics of such firms in the sample: there are indeed few of them and some large entries are the result of mergers.
- There is a negative impact on entry of the strictness of employment protection legislation.[22] At first glance this effect seems to be complex (Equation H): tight regulations on hiring and firing appear to increase entries of micro firms, while lowering those of small/medium-sized ones, *ceteris paribus*. However, this finding is consistent with the fact that in a number of countries with relatively tight EPL (*e.g.* Germany, Italy, Portugal), firms below a given size threshold (ranging from 5 to 25 employees) are exempted from certain aspects of the employment protection legislation.[23] Under these circumstances, firm entry seems to shift towards either smaller units – partially exempted from EPL – or to significantly larger ones, for which hiring and firing costs play a smaller role in total expected entry costs, as well as in the subsequent costs of adjusting the workforce.[24]

In summary, taken at face value these results suggest a statistically significant (albeit not large) direct effect of regulation on entry rates. In particular, a reduction in the administrative barriers to entrepreneurial activity equal to two standard deviations (calculated on the basis of the cross-country distribution) could lead to an increase in entry rates amongst small firms by about 1.3 percentage points (around 10 per cent of the cross-country average in entry rates). An easing of employment protection legislation of the same magnitude could raise entry rates amongst small- and medium-sized firms by about 0.7 percentage points. These are direct effects, to which may be added possible indirect effects stemming from the impact of these regulatory reforms on productivity and, possibly, on the size distribution of firms (see Nicoletti *et al.*, 2001).

4.5. Concluding remarks

A key finding of the firm-level analysis presented in this chapter is that over a five-year horizon, aggregate labour productivity growth is mainly driven by what happens in each individual firm, whilst shifts in market shares from low- to high-productivity firms and net entry seem to play only a modest role. However, this conclusion should be qualified on two grounds:

- First of all, there is tentative evidence suggesting that within-firm growth makes a smaller contribution to multi-factor productivity growth than it does to labour productivity growth. Since multi-factor productivity growth is a proxy for overall efficiency in the production process, this result suggests that incumbents often raise labour productivity by increasing capital intensity and/or shedding labour, while new firms provide a relatively larger contribution to overall efficiency, possibly by entering the market with a more "efficient" mix of capital and labour and likely new technologies.
- More importantly, even in terms of labour (rather than multi-factor) productivity, there are some industries where the entry of new units significantly boosts industry-wide growth. This is clearly the case for high-tech industries, where new firms are more likely to adopt state-of-the-art technologies. Interestingly, the United States, the country at the forefront in adopting new technologies over the recent period,has also displayed greater variability of productivity levels amongst entering firms than other countries for which the data was available.

The analysis of firm dynamics presented in this chapter points to a significant and broadly similar degree of "firm churning" amongst OECD countries. More specifically, the high correlation between entry and exit rates across industries suggests a process of "creative destruction" in which a large number of new firms displace a large number of inefficient firms. This does not prevent the likelihood of failure of entrants from being high, especially for small firms, which suggests that "creative destruction" also involves a great deal of market experimentation. However, surviving firms tend to grow rapidly towards the average (efficient) size.

Both European and US firms share these general features, but to a somewhat different extent. US entrant firms appear to be smaller and less productive than their European counterparts, but grow faster when successful. The econometric results presented in this chapter offer some rationale for these differences. Indeed, they support the view that strict regulations on entrepreneurial activity, as well as high costs of adjusting the workforce negatively affect the entry of new (especially small) firms. Thus, in the United States, low administrative costs of start-ups, and not unduly strict regulations on labour adjustments, are likely to stimulate potential

entrepreneurs to start on a small scale, test the market and, if successful with their business plan, expand rapidly to reach the minimum efficient scale. In contrast, higher entry and adjustment costs in Europe may stimulate a pre-market selection of business plans with less market experimentation. In addition, the more market-based financial system may lead to a lower risk aversion to project financing in the United States, with greater financing possibilities for entrepreneurs with small or innovative projects, often characterised by limited cash flows and lack of collateral.

There is no evidence in the available data that one model dominates the other in terms of aggregate performance. However, in a period (like the present) of rapid diffusion of a new technology (ICT), greater experimentation may allow new ideas and forms of production to emerge more rapidly, thereby leading to a faster process of innovation and technology adoption. This seems to be confirmed by the strong contribution to overall productivity made by new firms in ICT-related industries over the recent period (see Chapter 3 above). In this context, easing regulations may stimulate firm entry and, *via* this channel, may ultimately lead to higher productivity growth.

Notes

1. It would, however, have been somewhat larger had the decomposition followed the approach proposed by Foster *et al.* (1998) (see Scarpetta *et al.* (2002) for more details). Their methodology uses base-year market shares as weights for each term of the decomposition, and includes an additional term (the so-called "covariance" or "cross" term) that combines changes in market shares and changes in productivity. This term is positive if enterprises with growing productivity also experience an increase in market share, and negative otherwise. When labour productivity growth in manufacturing was decomposed along these lines, the "cross" term appeared to be negative, implying that firms experiencing an increase in productivity were also losing market shares, *i.e.* their productivity growth was associated with restructuring and downsizing rather than expansion. Under these circumstances, the overall contribution to GDP growth of these firms is lower than that for labour productivity and may even be negative.
2. These results are broadly consistent with findings in Baily *et al.* (1992) and Haltiwanger (1997).
3. For France and Italy, the data are somewhat problematic in the context of an international comparison, and should, therefore, be interpreted with great care. The French data refer to firms with at least 20 employees or with a turnover greater than EUR 0.58 m, which are not likely to be representative of the total population. In addition, larger firms may be over-sampled, lowering the net entry effect and raising the within effect. The Italian data refer to firms with a turnover of at least EUR 5 m, and sample size is maintained by deleting firms falling below the threshold and adding new firms in. Thus, the Italian data are likely to overstate true entry and exit rates. Furthermore, the sampling rules are likely to over-record exiting firms with falling productivity (see Scarpetta *et al.*, 2002).
4. The share of activity (the weighting factor in the decomposition, see Box 3.3) of entrants in the end year increases with the horizon over which the end year is measured (see Foster *et al.*, 1998).

5. See Baily *et al.* (1996, 1997) and Haltiwanger (1997).
6. The industry group is "*electrical and optical equipment*". In the United States, most 3-4 digit industries within this group had a positive contribution to productivity stemming from entry. In the other countries, there are cases where, within this group, the contribution from entry is very high, including the "*office, accounting and computing machinery*" industry in Finland, the United Kingdom and Portugal and "*precision instruments*" in France, Italy and the Netherlands.
7. In particular, Chapter 1 has shown that in many continental European countries high labour productivity growth in the 1990s was accompanied by significant falls in employment, especially in manufacturing. Moreover, the relatively high labour productivity growth was accompanied by significant falls in MFP growth with respect to the previous decade.
8. See *e.g.* Geroski (1991), Baldwin and Gorecki (1991).
9. The values reported in the Figure 4.5 are the estimated country-specific effects of a panel regression of entry rates on a set of dummy variables accounting for industry, country and time effects.
10. Indeed, the different size structure of firms across countries is not included in the country fixed effects of the panel data regression.
11. The lower turnover rate in the French service sector, compared with that in manufacturing, is likely to depend on the existence of a size threshold in the French data (see Scarpetta *et al.*, 2002), which tends to be more binding in the service sector than in manufacturing. As an indication, the French data also suggest a higher average size of firms in the service sector than in manufacturing, in contrast with all other countries.
12. The very high positive effect for the *post and telecommunication* industry is likely to be due to two factors: *i)* the privatisation of telecommunications in a number of countries which has led to the entry of a number of new private operators; and *ii)* the rapid increase in the number of firms operating in the communications area, related to the spread of Internet and e-commerce activities.
13. For example, a study of 46 products in the United States by Gort and Klepper (1982) found a typical initial phase of entry of about 10 years and a phase of contraction of about 5 years.
14. Following specific products over time would have led to more direct evidence, but in the context of this book such data were not available.
15. The corresponding results are not reported here. See Scarpetta *et al.* (2002).
16. In Table 4.4, hazard rates at duration *i* are the estimated probabilities of exiting the market conditional on having survived for at least *i* years.
17. See also Geroski (1995) and Audretsch and Mahmood (1994).
18. The results for the United States are consistent with the evidence in Audretsch (1995).
19. There is also a greater variability of productivity levels amongst entering in the United States compared with European countries, which is also consistent with the idea of greater "experimentation". However, there are other additional factors that could contribute to explain the observed differences in post-entry behaviour, including the larger size of the US market compared to that of EU countries. See Bartelsman *et al.*, 2002 for details on these factors.

20. See Geroski (1995) and Siegfried and Evans (1994) for a survey.

21. Such robustness is reassuring, because the lack of sectoral or time dimensions in the PMR indicators used in equations C, D and F of Table 4.6 implied that no additional control for country fixed effects could be included in equations. This could have potentially led to assigning an explanatory power to these regulatory indicators, which was, in fact, due to other omitted country-specific influences.

22. From an empirical point of view, the inclusion of EPL in the regression is problematic, given the high correlation with the overall indicator of product market regulation. In order to identify the two effects, equation H uses the *sector-specific* indicator of product market regulation, together with a *nation-wide* – but time-varying – indicator of EPL. In other words, the time dimension allows identification of the EPL coefficient, the sectoral dimension identifies the product market indicator, and the inclusion of country dummies minimises the risk of an omitted variable problem.

23. These results also seem consistent with those presented in Nicoletti *et al.* (2001) pointing to a negative effect of EPL on the average size of firms.

24. Indeed, the incidence of strict EPL on total labour adjustment costs may decline with the size of the firm, as larger ones may more easily reallocate labour within them and spread these costs over a larger capital stock. Nevertheless, this argument is insufficient to explain the positive effect of EPL found for very large firms (500 employees and more). As stressed above in the text, this result should not be overemphasised, insofar as there are a relatively small number of observations for this size class across industries and countries.

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Annex 1

Macroeconomic indicators of economic growth

A1.1. Measurement of labour and capital inputs

Measures of factor use for the purpose of productivity analysis are constructed so as to reflect the role that each factor plays as input in the production process. In the case of labour input, different types of labour should be weighted by their marginal contribution to the production activity in which they are employed. Since these productivity measures are generally not observable, information on relative wages by characteristics is used to derive the required weights to aggregate different types of labour. Concerning physical capital, Jorgenson (1963) and Jorgenson and Griliches (1967) were the first to develop aggregate capital input measures that took the heterogeneity of assets into account. They defined the flow of quantities of capital services individually for each type of asset, and then applied asset-specific user costs as weights to aggregate across services from the different types of assets. User costs are prices for capital services and, under competitive markets and equilibrium conditions, these prices reflect marginal productivity of the different assets. User cost weights are thus a means to effectively incorporate differences in the productive contribution of heterogeneous investments as the composition of investment and capital changes. Changes in aggregate capital input, therefore, have two distinct sources – changes in the quantity of capital of a given type, and changes in the composition of the various types of assets with different marginal products and user costs (Ho *et al.*, 1999).

Productivity growth measures without adjustment for different types of factor input

The following notation is used to discuss factor productivity with and without control for quality effects:

- Y Current price value-added;
- P Price index of value-added;
- N Total number of persons engaged;
- H Average hours worked per person;
- N*H Total hours worked;
- K Aggregate gross capital stock.

Letting lower case letters represent logarithms and Δ the first difference operator, Δx approximates the (instantaneous) growth rate of any variable x. The standard measure of factor productivity growth rates, $\Delta\pi_L$ *and* $\Delta\pi_K$ are given by:

$\Delta\pi_L = \Delta y - \Delta p - (\Delta n + \Delta h)$ Labour productivity

$\Delta\pi_K = \Delta y - \Delta p - \Delta k$ Capital productivity

This standard specification does not differentiate between different types of inputs: it attaches the same weight to each hour worked, and it does not differentiate between assets even though their marginal contribution to output may be quite different. Such differentiation can be introduced when there is information on quantities and prices of the different types of factor inputs. In the case of labour, prices will represent the skill-specific wage rate, and in the case of capital the asset specific rental price or user cost of capital. In what follows different types of labour and capital will be distinguished by the subscript j.

Productivity growth measures with adjustment for different types of factor input

Given a set of observations on different types of labour or capital and a set of corresponding prices, $w_{j,t}$ it is possible to construct an aggregate variable F that combines quantities of different types of inputs to a measure of total, quality-adjusted labour or capital input. In this regard, productivity studies often use the Törnqvist index and this practice is followed here. A Törnqvist index of factor input F is given by the expression below, where $v_{j,t}$ stands for the share of the component j in total costs of the factor. This is a conceptually correct measure for the flow of the total quantity of labour or capital services:

$$\Delta f_t(adj) = \sum_j \bar{v}_{j,t} \cdot \Delta f_{j,t} \qquad \text{where } \bar{v}_{j,t} = \frac{1}{2}\left(v_{j,t} + v_{j,t-1}\right) \text{ and } v_{j,t} = \frac{w_{j,t}F_{j,t}}{\sum_i w_{i,t}F_{i,t}}. \qquad [A1.1]$$

Thus, the growth rate of total factor input Δf, using the Törnqvist index, is a weighted average of the growth rates of different components. Weights correspond to the current price share in the overall cost for each factor. Subtracting the unadjusted measure of factor input from the one adjusted for compositional changes yields an expression Δcf for the effects of changing factor quality on total factor input services:

$$\Delta cl = \Delta l(adj) - (\Delta n + \Delta h) \qquad [A1.2]$$

$$\Delta ck = \Delta k(adj) - \Delta k \qquad [A1.3]$$

Equations [A1.2] and [A1.3] can be rearranged to yield a decomposition of the overall growth in factor input:

$\Delta l(adj) = \Delta cl + \Delta n + \Delta h$

$\Delta k(adj) = \Delta ck + \Delta k$

Labour input

In order to consider changes in the composition of labour input, six different types of labour were considered, based on gender and three different educational levels: below upper secondary education; upper secondary education and tertiary education. Thus, following equation A1.1 and assuming that L_j indicates the labour input jth with $j = 1, 2, ..6$ and that each type of labour is remunerated with wage rate w_j, then a measure of adjusted labour input can be obtained. There are, however, a number of issues worth noting, including:

- First, it is assumed that the rate change in average weekly or yearly hours is identical between education and gender groups, *i.e.* $\Delta h_{,j} = \Delta h$ for all j. This simplification can be used, in conjunction with the relation $\Delta l_{,j} = \Delta n_{,j} + \Delta h_{,j}$.
- Second, data on relative wage rates by educational attainment and gender are only available for the 1990s, and relative wage rates were thus assumed to be constant over the period considered in the analysis. More specifically, for the six available categories of education and gender, the wage spread was computed as $\frac{w_j}{w_{M,U-SE}}$, $j = 2, 3, 4, 5, 6$ as each education category's wage rate relative to wages of male workers with upper-secondary education ($w_{M,U\text{-}SE}$).
- The weights $v_{j,c}$ from equation [A1.1] for country c can be rewritten in terms of relative wages:

$$v_{j,c} = \frac{w_{j,c} N_{j,c}}{\sum_{i=1}^{6} w_{i,c} N_{i,c}} = \frac{\frac{w_{j,c}}{w_{M,U-SE,c}} N_{j,c}}{\sum_{i=1}^{6} \frac{w_{i,c}}{w_{M,U-SE,c}} N_{i,c}}$$

Capital input[1]

Standard measures of capital (based on aggregation of stocks made up of a moving sum of investment at real acquisition prices) rely on two assumptions: 1) the flow of capital services is a constant proportion of an estimated measure of the capital stock and, thus, the rate of change of capital services over time coincides with the rate of change of the capital stock as

estimated by cumulating measurable investment according to assumptions about asset lifetimes, physical depreciation, etc; and 2) the aggregate capital stock is made up of one homogenous type of asset or alternatively different assets that generate the same marginal revenues in production.

Alternatively, Jorgenson and Griliches (1967) proposed to compute growth rates of capital service of individual assets given information on investment flows, on the service life and on the profile of wear and tear of an asset. Then they suggested aggregating these different capital assets by their marginal productivities, proxied by user costs. User costs are composed of: *i)* the opportunity cost of investing money in financial (or other) assets rather than in a capital good; *ii)* the physical depreciation, *i.e.* the loss in efficiency/ productivity of the capital asset as it ages; and *iii)* the (expected) capital gain or loss (change in the real value of the asset unrelated to physical depreciation). These three components are reflected in the following expression, where q_j is the asset's acquisition price, r is the real rate of interest, and d_j is the asset-specific rate of depreciation. Following the expression in [A1.1] above, the weighting factor for each asset μ_j is proxied by the user cost as:

$$\mu_{j,t} = q_{j,t}\left(r_t + d_{j,t} - \frac{\Delta q^e_{j,t+1}}{q_{j,t}}\right) = q_{j,t}(r_t + d_{j,t}) - \Delta q^e_{j,t+1} \qquad \text{[A.1.4]}$$

The inclusion of the market depreciation ($-\Delta q_j$) as well as its exact quantification have been debated in the literature. Griliches himself (Griliches, 1987) suggests that only physical depreciation should be considered in the user cost, but not the market depreciation. The choice is in fact model dependent. In a putty-clay vintage model productivity is unchanged during the machine's whole lifetime; therefore, if the lifetime is sufficiently long, the marginal productivity of capital can be approximated by the right-hand side of equation [A.1.4] without the market depreciation term. Alternatively, equation [A.1.4] can be rationalised through the evolution along the balanced growth path of a putty-putty vintage model with perfect foresight (*i.e.*, $q^e_i = q_i$). However, outside the balanced growth path, market depreciation in a putty-putty vintage model should be introduced in equation [A.1.4] in expected terms.[2] In practice, the expression proposed by Jorgenson and Griliches (1967), the one more commonly used in the literature, assumes extrapolative expectations, while an expression without market depreciation could be rationalised through myopic expectations.

The capital service measure used here is taken from Colecchia and Schreyer (2002). It is calculated for nine countries (including the G-7) on the basis of an aggregation across seven types of capital goods (including three ICT capital goods – IT hardware, communications equipment and software), weighted with their user costs also considering capital gains or losses and

hedonic deflators. Given the great heterogeneity of physical capital assets, this is still a fairly high level of aggregation. As a matter of comparison, Jorgenson generally uses a decomposition of capital into 69 different assets.

Given the time series on $K^P_{j,t}$ and $\mu_{j,t}$, asset specific weights $v_{j,t}$ as in equation [A1.1] are given by:

$$v_{j,t} = \frac{\mu_{j,t} K^P_{j,t}}{\sum_{i=1}^{6} \mu_{i,t} K^P_{i,t}}$$

A1.2. Estimates of trend output and trend labour productivity

This section describes the method used to estimate trend time series in Chapter 1: the extended Hodrick-Prescott filter (Hodrick and Prescott, 1997). Actual and trend figures for growth in GDP, GDP per capita and GDP per person employed (in the whole economy and in the business sector only) are presented in Tables A1.1 to A1.8. The Hodrick-Prescott (H-P) filter belongs to a family of stochastic approaches that treats the cyclical component of observed output as a stochastic phenomenon. The cyclical component (demand shocks) is separated from the permanent component (supply shocks) under the assumption that the former has only a temporary effect, while the latter persists. The H-P filter is derived by minimising the sum of squared deviations of the log variable (*e.g.* GDP) (*y*) from the estimated trend τ_y, subject to a smoothness constraint that penalises squared variations in the growth of the estimated trend series. Thus, H-P trend values are those that minimise:

$$HP(\lambda) = \sum \left(y_t - \tau_{y,t}\right)^2 + \lambda \sum \left[\left(\tau_{y,t+1} - \tau_{y,t}\right) - \left(\tau_{y,t} - \tau_{y,t-1}\right)\right]^2 \qquad \text{[A.1.5]}$$

The estimated trend variable τ_y is a function of λ and both past and future values of y. Higher values of λ imply a large weight on smoothness in the estimated trend series (for very large values the estimated trend series will converge to a linear time trend). Apart from the arbitrary choice of the λ parameter (set to the standard value of 400 for semi-annual time series), the H-P filter may lead to "inaccurate" results if the temporary component contains a great deal of persistence. The distinction between temporary and permanent components then becomes particularly difficult, especially at the end of the sample when the H-P filter suffers from an in-sample phase shift problem.

In order to reduce the end-of-sample problem, the H-P filter is modified to take into account the information carried by the average historical growth rate (Butler, 1996, Conway and Hunt, 1997). Thus, trend values obtained

through the Extended Hodrick-Prescott filter (EHP) would be those that minimise:

$$EHP(w_1, w_2, \lambda) = \sum w_1 \left(y_t - \tau_{y,t}\right)^2 + \sum w_2 \left(\Delta\tau_{y,t} - g_{y,T_1,T_2}\right)^2 + \lambda \sum \left[\left(\tau_{y,t+1} - \tau_{y,t}\right) - \left(\tau_{y,t} - \tau_{y,t-1}\right)\right]^2 \qquad [A1.6]$$

where the two w parameter vectors are the vectors of weights attached to the gap terms, $\Delta\tau_y$ is the growth rate of estimated trend output and g is the historical growth rate between dates T_1 and T_2. The choice of weights determines the importance of the two gaps in the minimisation problem. In the estimations used in Chapter 1, w_1 is set equal to 1 in the sample period and to 0 afterwards, w_2 is set equal to 0 in the sample period and to 1 afterwards. Given the objective of estimating recent growth patterns, this way to solve the end-point problem can be considered as a prudent approach. In fact it underestimates sharp deviations from the historical pattern in the neighbourhood of the end of the sample. On the other hand, its estimates can be considered as a lower bound in the case of acceleration of the growth rate in the most recent years (or *vice versa* in the case of deceleration).[3]

The end-point problem is not the only severe theoretical pitfall of the H-P filter. When the supply-side components are subject to temporary stochastic shocks with greater variance than that of the demand-side component, or when the demand-side component has a significant degree of persistence, the decomposition of cycle and trend estimated by an H-P filter turns out to be inaccurate (see *e.g.* Harvey and Jaeger, 1993, and Conway and Hunt, 1997). Scarpetta et *al.* (2000) also present a sensitivity analysis in which the extended H-P series of GDP growth are compared with those based on a Multivariate filter (MV). With the MV filter, information about the output-inflation process (Philips Curve) and the employment-output process (Okun's law) is thus included in the optimisation problem.[4] To the extent that these two processes are well identified, data on inflation and employment help in the identification of trend output. The combined estimation of trend output, the Phillips curve and the Okun's curve guarantee consistent estimation of trend output and trend employment. Moreover, the ratio of the two series yields a consistent measure of trend labour productivity. Also in this case, estimates of trend GDP growth rates are broadly consistent with those obtained by the extended H-P filter discussed above.

A1.3. Sensitivity analysis of multi-factor productivity growth

Table 1.3 and Figure 1.8 in Chapter 1 report estimates of Multi-Factor Productivity (MFP) growth, based on trend series for value-added, employment, hours worked and capital stock and on time-varying factor shares. Moreover, Table 1.3 also presents alternative measures of MFP growth that take into account changes in the composition and quality of labour and capital inputs for the G7 countries, Australia and Finland. Results and

interpretation of different MFP measures are discussed in the main text and are not repeated here. This section expands further the sensitivity analysis by reporting measures of MFP growth based on actual series and average factor shares.

In principle, it can be expected that the use of trend, rather than actual, time series makes little difference for average MFP growth rates over a long period (*e.g.* 10 years). Conversely, over a shorter period, averages of trend growth rates of MFP can be rather different from averages of actual growth rates, since the latter incorporate short-run dynamics due to partial adjustment, cyclical phenomena and the effect of transitory shocks. Table A1.9 reports various MFP growth rates (adjusted for hours worked). As expected, differences between MFP growth rates based on actual and trend series are small except for the period 1996-2000 for a few countries. In particular, trend series yield a higher average MFP growth rate in the 1990s (and especially in the second half of the decade) in Japan where the protracted sluggish GDP growth weighs heavily in the estimation of MFP based on actual data. Conversely, MFP average growth based on actual data tends to be higher than that based on trend series in most of the other OECD countries, and especially in those where growth, in particular in the second half of the 1990s, was buoyant. The Table also suggests that the use of average factor shares instead of time-varying factor shares to weight factor inputs does not affect markedly estimated MFP growth.

Table A1.1. Actual GDP growth in the OECD area, by sub-period

Total economy, percentage change at annual rate

Total economy	1970-00	1970-80	1980-90	1990[1]-00	1996-00	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	3.2	3.2	3.2	3.2	4.2	1.8	–0.5	3.1	2.7	4.0	2.7	3.6	4.4	4.3	4.1	4.1
Japan	3.3	4.4	4.1	1.3	0.7	5.3	3.1	0.9	0.4	1.0	1.8	3.5	1.8	–1.1	0.8	1.5
Germany	..	..	..	1.6	2.0	..	..	1.8	–1.1	2.3	1.7	0.8	1.4	2.0	1.8	3.0
western Germany	2.5	2.7	2.2	..	..	5.7	..	..	..	..	..	..	..	..	..	..
France	2.5	3.3	2.4	1.8	2.9	2.6	1.0	1.3	–0.9	1.8	1.9	1.1	1.9	3.5	3.0	3.4
Italy	2.5	3.6	2.2	1.6	2.1	2.0	1.4	0.8	–0.9	2.2	2.9	1.1	2.0	1.8	1.6	2.9
United Kingdom	2.3	1.9	2.7	2.3	2.9	0.8	–1.4	0.2	2.5	4.7	2.9	2.6	3.4	3.0	2.1	2.9
Canada	3.3	4.3	2.8	2.8	4.4	0.2	–2.1	0.9	2.4	4.7	2.8	1.6	4.3	3.9	5.1	4.4
Australia	3.3	3.2	3.2	3.5	4.2	1.3	–0.6	2.4	3.9	4.7	4.1	4.1	3.5	5.4	4.5	3.4
Austria	2.8	3.6	2.3	2.3	2.7	4.7	3.3	2.3	0.4	2.6	1.8	2.0	1.6	3.5	2.8	3.0
Belgium	2.5	3.4	2.1	2.1	3.2	2.9	1.8	1.6	–1.5	2.8	2.8	1.2	3.8	2.2	3.0	4.0
Czech Republic	..	..	..	1.5	0.1	..	..	..	–0.9	2.6	5.9	4.3	–0.8	–1.2	–0.4	2.9
Denmark	2.2	2.2	1.9	2.3	2.8	1.0	1.1	0.6	0.0	5.5	2.8	2.5	3.0	2.8	2.1	3.2
Finland	2.9	3.5	3.1	2.2	5.3	0.0	–6.3	–3.3	–1.1	4.0	3.8	4.0	6.3	5.3	4.0	5.7
Greece	2.5	4.6	0.7	2.3	3.7	0.0	3.1	0.7	–1.6	2.0	2.1	2.4	3.6	3.4	3.4	4.3
Hungary	..	..	..	2.3	4.7	..	..	–3.1	–0.6	2.9	1.5	1.3	4.6	4.9	4.2	5.2
Iceland	3.9	8.3	2.7	2.6	4.8	1.1	0.7	–3.3	0.6	4.5	0.1	5.2	4.8	4.6	4.0	5.0
Ireland	5.2	4.7	3.8	7.3	10.4	8.5	1.9	3.3	2.7	5.8	10.0	7.8	10.8	8.6	10.8	11.5
Korea	7.5	7.6	8.9	6.1	4.3	7.8	9.2	5.4	5.5	8.3	8.9	6.8	5.0	–6.7	10.9	8.8
Luxembourg	4.3	2.6	4.5	5.9	7.1	2.2	6.1	4.5	8.7	4.2	3.8	3.6	9.0	5.8	6.0	7.5
Mexico	4.0	8.6	1.8	3.5	5.6	5.1	4.2	3.6	2.0	4.5	–6.2	5.1	6.8	4.9	3.8	6.9
Netherlands	2.7	2.9	2.2	2.9	3.8	4.1	2.3	2.0	0.8	3.2	2.3	3.0	3.8	4.3	3.7	3.5
New Zealand	2.2	1.6	2.5	2.6	2.2	0.8	–1.9	0.8	4.7	8.1	3.9	3.3	2.9	–0.6	3.7	3.0
Norway	3.5	4.7	2.4	3.4	2.6	2.0	3.1	3.3	3.1	5.5	3.8	4.9	4.7	2.4	1.1	2.3
of which: Mainland	2.9	4.4	1.5	2.8	2.8	1.0	1.4	2.2	2.8	4.1	2.9	3.8	4.2	3.6	1.0	1.8
Poland	..	..	..	3.6	4.9	..	–7.0	2.5	3.7	5.2	7.0	8.0	6.8	4.9	4.0	4.0
Portugal	3.5	4.7	3.2	2.7	3.6	4.4	2.3	2.5	–1.1	2.2	2.8	3.7	3.8	3.8	3.3	3.3
Spain	3.0	3.5	2.9	2.6	4.1	3.8	2.5	0.9	–1.0	2.4	2.8	2.4	4.0	4.3	4.1	4.1
Sweden	1.9	1.9	2.2	1.7	3.3	1.1	–1.1	–1.7	–1.8	4.1	3.7	1.1	2.1	3.6	4.1	3.5
Switzerland	1.4	1.4	2.1	0.9	2.2	3.7	–0.8	–0.1	–0.5	0.5	0.5	0.3	1.7	2.4	1.6	3.0
Turkey	4.3	4.1	5.2	3.6	3.1	9.3	0.9	6.0	8.0	–5.5	7.2	7.0	7.5	3.1	–4.7	7.2
Coefficient of variation																
OECD total	0.38	0.41	0.51	0.51	0.83											
EU 15	0.30	0.28	0.34	0.58	0.80											
OECD 24[2]	0.28	0.35	0.34	0.51	0.87											

1. 1991 for Germany and Hungary, 1992 for Czech Republic.
2. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.2. Actual GDP per capita growth in the OECD area, by sub-period

Total economy, percentage change at annual rate

Total economy	1970-00	1970-80	1980-90	1990[1]-00	1996-00	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	2.2	2.1	2.2	2.2	3.3	0.7	–1.5	1.9	1.6	3.0	1.7	2.8	3.4	3.3	3.2	3.2
Japan	2.8	3.3	3.5	1.1	0.5	5.0	2.8	0.6	0.2	0.8	1.1	3.2	1.6	–1.4	0.6	1.4
Germany	..	..	..	1.3	2.0	..	..	1.5	–1.8	2.0	1.4	0.5	1.2	2.0	1.8	2.9
western Germany	1.5	2.6	2.0	..	..	3.7	..	..	..	..	..	..	..	..	..	..
France	2.0	2.7	1.8	1.4	2.8	2.1	0.8	0.8	–1.3	1.5	1.5	0.7	1.6	3.2	2.6	2.9
Italy	2.2	3.1	2.2	1.4	1.9	3.4	1.3	0.6	–1.2	1.9	2.7	0.9	1.8	1.7	1.5	2.7
United Kingdom	2.1	1.8	2.5	1.9	2.4	0.4	–1.8	–0.1	2.2	4.3	2.5	2.3	3.1	2.6	1.7	2.4
Canada	2.0	2.8	1.5	1.7	3.5	–1.3	–3.3	–0.4	1.2	3.5	1.7	0.5	3.2	3.0	4.2	3.6
Australia	1.9	1.5	1.7	2.3	3.0	–0.2	–1.9	1.2	2.9	3.6	2.9	2.8	2.3	4.3	3.4	2.2
Austria	2.5	3.5	2.1	1.8	2.6	3.4	1.9	1.5	–1.0	2.1	1.4	1.8	1.4	3.4	2.6	2.8
Belgium	2.3	3.2	2.0	1.8	3.0	2.6	1.4	1.2	–1.9	2.4	2.2	1.2	3.3	2.0	2.8	3.8
Czech Republic	..	..	..	1.6	0.2	..	..	..	–1.1	2.6	6.0	4.4	–0.6	–1.1	–0.3	3.0
Denmark	1.9	1.8	1.9	2.0	2.4	0.8	0.9	0.3	–0.3	5.1	2.3	1.9	2.5	2.4	1.8	2.9
Finland	2.5	3.1	2.7	1.8	5.0	–0.4	–7.1	–3.6	–1.6	3.5	3.4	3.7	8.0	5.1	3.7	5.5
Greece	1.9	3.6	0.2	1.9	3.5	–0.5	2.0	–0.5	–2.1	1.6	1.8	2.3	3.3	3.2	3.4	4.1
Hungary	..	..	..	3.4	5.1	..	..	..	–0.3	3.3	1.8	1.7	5.0	5.3	4.6	5.6
Iceland	2.8	5.2	1.6	1.6	3.4	0.3	–0.5	–4.5	–0.4	3.6	–0.4	4.8	4.0	3.5	2.7	3.5
Ireland	4.3	3.3	3.3	6.4	9.2	8.8	1.3	2.6	2.3	5.2	9.4	7.0	9.8	7.3	9.7	10.2
Korea	6.2	5.8	7.6	5.1	3.3	6.8	8.1	4.3	4.4	7.2	7.8	5.7	4.0	–7.6	9.9	7.8
Luxembourg	3.4	1.9	3.9	4.5	5.7	0.6	4.7	3.0	7.2	2.7	2.2	2.9	7.6	4.5	4.5	6.0
Mexico	1.5	3.3	–0.3	1.7	4.2	3.0	2.2	1.6	0.0	2.4	–8.1	2.9	4.8	3.0	1.8	7.1
Netherlands	2.0	2.1	1.6	2.2	3.2	3.4	1.4	1.3	0.1	2.6	1.7	2.8	3.3	3.7	3.0	2.7
New Zealand	1.2	0.5	1.9	1.2	1.4	–0.4	–5.1	–0.2	3.5	4.7	2.4	1.7	1.6	–1.5	3.2	2.5
Norway	3.0	4.2	2.0	2.8	2.0	1.6	2.6	2.7	2.5	4.9	3.3	4.4	4.1	1.8	0.4	1.6
of which: Mainland	2.4	3.8	1.1	2.2	2.0	0.6	0.9	1.6	2.2	3.5	2.4	3.3	3.6	3.0	0.4	1.2
Poland	..	..	..	3.5	4.9	..	–7.3	2.2	3.5	5.0	8.9	5.9	6.8	4.8	4.0	4.0
Portugal	3.0	3.4	3.1	2.5	3.2	4.8	2.5	2.9	–1.2	2.2	2.8	3.5	3.7	2.9	3.1	3.1
Spain	2.5	2.5	2.6	2.5	4.0	3.6	2.4	0.7	–1.2	2.2	2.6	2.3	3.9	4.2	4.0	4.0
Sweden	1.6	1.6	1.9	1.4	3.2	0.3	–1.8	–2.3	–2.4	3.4	3.2	0.9	2.0	3.5	4.0	3.4
Switzerland	1.0	1.2	1.5	0.2	1.8	2.7	–2.1	–1.2	–1.4	–0.6	0.2	–0.1	1.5	2.1	1.1	2.4
Turkey	2.1	1.8	2.8	1.8	1.5	6.7	–1.0	4.0	6.1	–7.1	5.3	5.2	5.8	1.4	–6.2	5.5
Coefficient of variation																
OECD total	0.44	0.43	0.61	0.58	0.55											
EU 15	0.31	0.26	0.38	0.60	0.52											
OECD 24[2]	0.32	0.40	0.35	0.59	0.56											

1. 1991 for Germany, 1992 for Czech Republic and Hungary.
2. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.3. **Actual GDP per person employed in the OECD area, by sub-period**

Total economy, percentage change at annual rate

Total economy	1970-00[1]	1970-80	1980[2]-90	1990[3]-00[1]	1996-00[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	1.4	0.8	1.4	1.9	2.6	0.5	0.4	2.4	1.1	1.7	1.2	2.1	2.1	2.8	2.5	2.8
Japan	2.5	3.6	2.8	1.0	0.9	3.3	1.2	–0.1	0.2	0.9	1.5	3.0	0.7	–0.4	1.6	1.8
Germany	..	..	..	1.5	1.1	..	..	3.8	0.3	2.5	1.5	1.1	1.6	0.9	0.6	1.3
western Germany	1.3	2.6	1.7	..	..	2.7	..	..	..	..	..	..	..	..	..	..
France	2.0	2.7	2.1	1.3	1.4	1.8	1.0	1.9	0.3	1.7	1.0	0.9	1.3	2.1	1.2	1.1
Italy	2.2	2.9	2.1	1.7	0.9	0.7	0.7	1.8	2.3	3.9	3.6	0.6	1.6	0.7	0.4	1.0
United Kingdom	1.9	1.7	2.0	2.0	1.5	0.5	1.7	2.4	2.9	3.7	1.5	1.5	1.4	1.8	0.9	1.8
Canada	1.1	0.8	1.1	1.4	1.8	0.2	–0.4	1.6	1.6	2.7	0.9	0.8	1.9	1.2	2.2	1.8
Australia	1.6	1.7	1.0	2.1	2.2	–0.2	1.5	3.1	3.5	1.5	0.0	2.7	2.6	3.6	2.2	0.4
Austria	2.3	3.0	2.1	1.9	1.8	3.0	1.9	2.1	1.1	2.7	1.6	2.6	1.1	2.7	1.4	2.1
Belgium	2.3	3.2	2.0	1.7	2.0	2.0	1.7	2.1	–0.8	3.1	1.9	0.8	2.8	1.0	1.6	2.4
Czech Republic	..	..	..	..	1.4	..	..	..	0.3	1.5	5.0	4.2	–0.2	0.2	1.9	3.7
Denmark	1.6	1.8	1.0	2.1	1.8	0.4	1.7	1.1	2.3	6.1	0.7	1.4	1.3	2.3	1.2	2.5
Finland	2.6	2.5	2.4	2.9	2.9	0.1	–1.2	4.1	5.3	4.8	1.6	2.6	4.2	2.9	0.7	3.9
Greece	1.8	4.0	–0.3	1.8	3.1	–1.3	5.6	–0.7	–2.4	0.1	1.2	2.7	4.3	–0.7	4.2	4.6
Hungary	..	..	..	4.2	3.1	..	..	7.2	6.2	6.5	3.4	1.9	4.3	3.4	0.5	4.2
Iceland	2.1	3.6	1.0	1.5	2.2	2.2	0.8	–1.9	1.4	4.0	–0.7	2.8	2.9	1.2	1.2	3.4
Ireland	3.4	3.8	3.6	3.0	3.2	3.9	2.2	2.8	1.2	2.4	4.8	3.7	6.9	–1.5	4.3	..
Korea	4.7	3.9	5.9	4.5	4.0	4.7	5.8	3.5	3.9	5.1	6.1	4.8	3.6	–1.5	9.3	4.8
Luxembourg	3.3	1.5	3.7	4.6	4.8	0.7	4.7	4.3	9.0	3.4	2.8	2.6	7.7	3.8	3.3	4.6
Mexico	..	..	0.1	0.3	1.8	2.2	1.4	–0.1	–1.7	1.2	–6.2	1.1	0.7	1.5	2.6	2.2
Netherlands	1.6	2.6	1.3	0.8	0.8	1.0	–0.3	0.4	0.1	3.3	–0.2	1.0	0.4	1.0	0.7	1.2
New Zealand	1.0	0.0	2.3	0.7	1.5	–0.3	–0.6	0.0	2.0	1.3	–1.2	–0.4	2.5	0.0	2.2	1.4
Norway	2.4	3.2	1.8	2.3	1.0	2.9	4.2	3.6	3.1	3.9	1.6	2.3	1.7	0.0	0.7	1.8
of which: Mainland	1.7	2.7	0.9	1.6	1.1	2.1	2.8	2.4	2.7	2.5	0.5	1.2	1.1	1.1	0.7	1.2
Poland	..	..	..	5.8	5.7	..	..	..	..	6.9	6.1	4.8	5.4	3.6	8.2	5.7
Portugal	2.1	3.0	1.7	1.7	1.5	2.1	–0.6	1.6	0.9	2.4	3.4	3.2	1.9	1.3	1.4	1.5
Spain	2.5	3.8	2.3	1.5	0.2	1.1	2.3	2.9	3.4	3.3	0.9	1.0	1.1	0.8	–0.5	–0.6
Sweden	1.7	1.0	1.6	2.5	2.1	0.1	0.9	2.6	4.2	5.1	2.1	1.7	3.2	2.1	1.8	1.3
Switzerland	0.7	1.2	0.3	0.6	1.6	0.6	–3.2	1.2	0.1	2.3	–0.1	–0.1	2.1	0.9	1.2	2.0
Turkey	2.7	2.2	3.6	2.5	2.9	7.4	–1.6	5.6	14.1	–11.9	4.6	4.5	7.7	0.6	–7.1	11.4
Coefficient of variation																
EU 15	0.28	0.33	0.49	0.45	0.59											
OECD 24[4]	0.34	0.46	0.53	0.46	0.52											

1. 1999 for Ireland.
2. 1983 for Mexico.
3. 1991 for Hungary and Germany, 1992 for Czech Republic, 1993 for Poland.
4. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.4. **Trend GDP growth in the OECD area, by sub-period**

Total economy, percentage change at annual rate

Total economy	1970-00	1970-80	1980-90	1990[1]-00	1996-00	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	3.1	3.0	3.1	3.3	3.7	2.7	2.6	2.6	2.8	3.0	3.3	3.5	3.7	3.8	3.8	3.7
Japan	3.4	4.7	3.9	1.7	1.1	3.7	3.2	2.6	2.1	1.8	1.5	1.4	1.2	1.1	1.0	1.1
Germany	..	..	..	1.5	1.7	..	..	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.8
western Germany	2.6	2.7	2.2	..	..	3.2	..		..	..	..	..	..	..	..	..
France	2.5	3.3	2.2	1.9	2.3	2.2	1.9	1.6	1.5	1.5	1.6	1.8	2.0	2.3	2.4	2.5
Italy	2.5	3.5	2.3	1.7	1.8	2.0	1.8	1.6	1.5	1.5	1.6	1.8	1.7	1.8	1.9	1.9
United Kingdom	2.3	1.9	2.5	2.4	2.7	2.1	1.9	1.9	2.1	2.3	2.5	2.7	2.7	2.7	2.7	2.6
Canada	3.1	4.0	2.6	2.8	3.6	1.9	1.7	1.8	2.0	2.4	2.7	3.1	3.3	3.6	3.7	3.7
Australia	3.3	3.3	3.1	3.6	4.0	2.9	2.9	3.0	3.2	3.5	3.7	3.9	4.0	4.0	4.0	3.8
Austria	2.8	3.5	2.3	2.4	2.5	2.9	2.8	2.6	2.4	2.3	2.2	2.2	2.3	2.4	2.5	2.6
Belgium	2.5	3.2	2.1	2.2	2.6	2.4	2.2	2.0	1.9	1.9	2.0	2.2	2.4	2.5	2.7	2.7
Denmark	2.2	2.3	1.9	2.2	2.7	1.3	1.4	1.5	1.8	2.1	2.4	2.6	2.7	2.7	2.7	2.6
Finland	2.9	3.5	2.6	2.5	4.1	0.7	0.2	0.3	0.8	1.6	2.4	3.2	3.8	4.2	4.3	4.2
Greece	2.5	4.4	0.9	2.2	2.9	1.4	1.4	1.4	1.5	1.7	2.0	2.4	2.7	2.9	3.0	3.0
Iceland	3.6	5.5	2.8	2.5	3.7	1.2	1.0	1.0	1.3	1.8	2.4	3.0	3.4	3.7	3.9	3.9
Ireland	5.1	4.6	3.3	7.4	9.1	4.6	4.8	5.2	5.7	6.5	7.3	8.1	8.7	9.1	9.3	9.4
Korea	7.5	8.1	8.4	8.1	5.2	8.4	7.9	7.4	6.9	6.5	8.0	5.8	5.2	5.0	5.2	5.4
Luxembourg	4.2	2.4	4.5	5.8	6.0	6.1	6.0	5.9	5.7	5.6	5.6	5.7	5.8	6.0	6.0	6.0
Mexico	3.9	6.2	2.1	3.4	4.1	2.6	2.8	2.8	2.7	2.7	2.9	3.2	3.7	4.1	4.3	4.5
Netherlands	2.7	2.9	2.1	3.0	3.3	2.9	2.8	2.7	2.7	2.7	2.9	3.1	3.2	3.3	3.4	3.4
New Zealand	2.1	1.9	2.0	2.5	2.6	1.4	1.6	2.0	2.4	2.8	3.0	2.9	2.8	2.7	2.8	2.5
Norway	3.5	4.3	2.8	3.3	3.2	2.5	2.8	3.1	3.4	3.6	3.7	3.7	3.5	3.2	3.0	2.9
of which. Mainland	2.8	4.1	1.8	2.6	2.8	1.2	1.5	1.9	2.4	2.7	3.0	3.1	3.0	2.9	2.7	2.5
Portugal	3.5	4.3	3.1	3.0	3.1	3.7	3.3	2.9	2.7	2.6	2.7	2.9	3.0	3.1	3.2	3.2
Spain	3.0	3.4	2.6	2.8	3.3	3.2	2.8	2.4	2.3	2.3	2.5	2.8	3.1	3.3	3.4	3.5
Sweden	2.0	2.1	2.0	1.8	2.7	1.1	0.8	0.8	1.0	1.3	1.7	2.1	2.4	2.7	2.8	2.8
Switzerland	1.4	1.3	1.9	1.1	1.5	1.7	1.3	0.9	0.7	0.7	0.8	1.0	1.2	1.4	1.6	1.7
Turkey	4.3	4.5	4.5	3.9	3.5	4.6	4.4	4.2	4.0	3.9	3.9	3.9	3.8	3.6	3.4	3.4
Coefficient of variation																
OECD total[2]	0.38	0.40	0.49	0.49	0.48											
EU 15	0.29	0.26	0.32	0.56	0.56											
OECD 24[3]	0.28	0.32	0.31	0.48	0.50											

1. 1991 for Germany.
2. Excluding Czech Republic, Hungary and Poland.
3. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.5. **Trend GDP per capita growth in the OECD area, by sub-period**

Total economy, percentage change at annual rate

Total economy	1970-00	1970-80	1980-90	1990[1]-00	1996-00	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	2.1	1.9	2.1	2.3	2.8	1.6	1.5	1.5	1.7	2.0	2.3	2.5	2.7	2.8	2.9	2.8
Japan	2.8	3.6	3.3	1.4	0.9	3.4	2.8	2.3	1.9	1.6	1.1	1.1	0.9	0.8	0.9	0.9
Germany	..	..	..	1.2	1.7	..	..	0.4	0.5	1.0	1.1	1.2	1.4	1.7	1.7	1.8
western Germany	1.5	2.5	1.9	..	..	1.2	..		..	..	..	..	..	..	..	..
France	1.9	2.7	1.6	1.5	1.9	1.7	1.4	1.2	1.1	1.2	1.3	1.5	1.7	1.9	2.0	2.0
Italy	2.3	3.0	2.3	1.5	1.7	3.5	1.7	1.4	1.1	1.2	1.4	1.5	1.5	1.7	1.8	1.7
United Kingdom	2.0	1.8	2.2	2.1	2.3	1.8	1.5	1.6	1.8	2.0	2.2	2.3	2.4	2.4	2.2	2.2
Canada	1.9	2.6	1.4	1.7	2.6	0.3	0.5	0.5	0.9	1.2	1.6	1.9	2.3	2.7	2.8	2.8
Australia	1.9	1.6	1.6	2.4	2.8	1.4	1.6	1.7	2.2	2.4	2.5	2.5	2.8	2.9	2.8	2.6
Austria	2.5	3.4	2.1	1.9	2.3	1.7	1.4	1.8	1.0	1.8	2.0	2.1	2.2	2.4	2.3	2.4
Belgium	2.3	3.0	2.0	1.9	2.3	2.1	1.8	1.6	1.5	1.6	1.6	2.2	2.1	2.3	2.4	2.5
Denmark	1.9	1.9	1.9	1.9	2.3	1.1	1.1	1.2	1.5	1.8	1.9	1.9	2.2	2.4	2.3	2.3
Finland	2.5	3.1	2.2	2.1	3.9	0.2	–0.8	0.0	0.3	1.1	2.0	2.9	3.5	3.9	3.9	4.0
Greece	1.9	3.4	0.5	1.8	2.7	0.9	0.3	0.2	1.0	1.3	1.8	2.3	2.3	2.7	3.0	2.8
Iceland	2.5	4.3	1.7	1.5	2.8	0.4	–0.3	–0.2	0.3	1.0	1.9	2.4	2.7	2.6	2.6	2.4
Ireland	4.2	3.1	3.0	8.4	7.9	4.9	4.2	4.4	5.3	5.9	6.8	7.3	7.7	7.8	8.2	8.2
Korea	6.2	6.3	7.2	5.1	4.2	7.3	6.8	6.3	5.8	5.4	5.0	4.5	4.2	4.1	4.2	4.5
Luxembourg	3.4	1.7	4.0	4.5	4.8	4.5	4.5	4.4	4.2	4.2	4.0	5.0	4.5	4.6	4.6	4.6
Mexico	1.5	2.9	0.0	1.6	2.7	0.6	0.8	0.8	0.8	0.7	0.8	1.0	1.7	2.2	2.3	4.7
Netherlands	2.0	2.1	1.6	2.4	2.7	2.2	1.9	1.9	1.9	2.1	2.4	2.8	2.7	2.7	2.7	2.7
New Zealand	1.1	0.8	1.4	1.2	1.8	0.4	–1.7	0.9	1.3	1.4	1.5	1.3	1.5	1.8	2.1	1.9
Norway	3.0	3.8	2.5	2.7	2.5	2.1	2.3	2.5	2.8	3.0	3.2	3.2	2.9	2.6	2.3	2.2
of which. Mainland	2.3	3.5	1.4	2.0	2.2	0.9	1.0	1.4	1.8	2.1	2.4	2.5	2.5	2.3	2.1	1.9
Portugal	3.0	3.0	3.1	2.8	2.7	4.2	3.4	3.3	2.6	2.6	2.6	2.7	2.9	2.2	3.0	2.9
Spain	2.4	2.3	2.3	2.7	3.2	3.0	2.8	2.2	2.1	2.1	2.3	2.8	2.9	3.2	3.3	3.4
Sweden	1.6	1.8	1.7	1.5	2.8	0.3	0.2	0.2	0.4	0.6	1.2	1.9	2.3	2.6	2.7	2.6
Switzerland	1.0	1.1	1.4	0.4	1.1	0.7	0.0	–0.2	–0.2	–0.5	0.5	0.5	0.9	1.1	1.1	1.1
Turkey	2.1	2.2	2.1	2.1	1.9	2.1	2.4	2.2	2.1	2.1	2.1	2.2	2.1	1.9	1.8	1.8
Coefficient of variation																
OECD total[2]	0.44	0.42	0.80	0.57	0.49											
EU 15	0.30	0.24	0.37	0.56	0.52											
OECD 24[3]	0.31	0.35	0.35	0.55	0.51											

1. 1991 for Germany.
2. Excluding Czech Republic, Hungary and Poland.
3. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.6. **Trend GDP per person employed in the OECD area, by sub-period**

Total economy, percentage change at annual rate

Total economy	1970-00[1]	1970-80	1980[2]-90	1990[3]-00[1]	1996-00[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	1.3	0.7	1.3	1.8	2.2	1.3	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.3	2.3
Japan	2.6	3.9	2.6	1.2	1.0	2.3	1.9	1.6	1.3	1.2	1.1	1.1	1.1	1.0	1.0	1.1
Germany	..	..		1.4	1.2	..	..	1.7	1.6	1.6	1.5	1.4	1.3	1.2	1.2	1.2
western Germany	1.3	2.7	1.6	..	..	1.9	..	..	..	..	..	..	..	..	..	..
France	2.0	2.8	2.0	1.4	1.3	1.9	1.7	1.5	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Italy	2.3	2.9	2.2	1.7	1.3	2.2	2.1	2.1	2.1	2.1	2.0	1.7	1.5	1.3	1.2	1.1
United Kingdom	1.9	1.9	1.9	1.8	1.7	1.5	1.7	1.8	2.0	2.0	2.0	1.9	1.8	1.7	1.7	1.6
Canada	1.1	0.9	0.9	1.4	1.6	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.8	1.6
Australia	1.6	1.8	1.1	1.9	2.0	1.1	1.4	1.6	1.8	1.9	2.0	2.1	2.1	2.1	1.9	1.8
Austria	2.4	3.1	2.1	2.0	2.0	2.3	2.2	2.1	2.1	2.0	2.0	2.0	2.0	1.9	1.9	2.0
Belgium	2.3	3.2	2.0	1.7	1.7	1.9	1.8	1.7	1.7	1.6	1.6	1.7	1.7	1.7	1.7	1.8
Denmark	1.6	1.8	1.1	1.9	2.0	1.2	1.5	1.8	2.0	2.1	2.1	2.1	2.0	2.0	1.9	1.9
Finland	2.6	2.6	2.4	2.9	2.9	2.4	2.5	2.7	2.9	3.0	3.0	3.0	3.0	2.9	2.8	2.8
Greece	1.8	3.7	0.1	1.6	2.3	1.0	1.0	0.9	0.9	1.1	1.3	1.7	2.0	2.2	2.4	2.5
Iceland	1.9	2.8	1.2	1.6	1.9	1.5	1.3	1.3	1.3	1.4	1.6	1.7	1.8	1.9	2.0	2.0
Ireland	3.5	4.0	3.2	3.5	3.8	3.5	3.3	3.2	3.1	3.2	3.4	3.5	3.7	3.8	3.9	..
Korea	4.8	4.4	5.6	4.4	4.3	5.0	4.8	4.6	4.5	4.4	4.3	4.2	4.2	4.2	4.3	4.4
Luxembourg	3.3	1.5	3.8	4.5	4.2	5.1	5.0	5.0	4.9	4.7	4.5	4.4	4.4	4.3	4.2	4.1
Mexico	..	..	–0.4	0.2	0.7	0.0	0.0	–0.1	–0.3	–0.3	–0.3	0.0	0.3	0.8	0.9	1.1
Netherlands	1.6	2.8	1.1	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
New Zealand	0.9	0.2	1.8	0.7	0.7	1.3	1.0	0.8	0.7	0.6	0.6	0.6	0.7	0.7	0.8	0.7
Norway	2.4	2.7	2.1	2.3	1.6	2.8	2.9	3.0	2.9	2.7	2.4	2.1	1.8	1.6	1.5	1.5
of which Mainland	1.7	2.4	1.1	1.6	1.3	1.6	1.8	1.9	1.9	1.8	1.6	1.5	1.4	1.3	1.2	1.2
Portugal	2.1	2.6	1.8	1.9	1.8	2.2	2.1	2.0	2.0	2.0	2.1	2.1	2.0	1.8	1.7	1.6
Spain	2.5	3.8	2.4	1.4	0.7	2.1	2.1	2.2	2.1	1.9	1.7	1.4	1.1	0.8	0.6	0.5
Sweden	1.7	1.2	1.7	2.4	2.2	1.9	2.1	2.3	2.6	2.7	2.7	2.8	2.5	2.3	2.1	2.0
Switzerland	0.7	1.3	0.2	0.7	1.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.1	1.1	1.2
Turkey	2.7	2.7	2.9	2.6	2.6	2.9	2.8	2.8	2.6	2.4	2.3	2.4	2.5	2.5	2.6	2.9
Coefficient of variation																
EU 15	0.28	0.30	0.44	0.45	0.50											
OECD 24[4]	0.35	0.43	0.48	0.45	0.47											

1. 1999 for Ireland.
2. 1983 for Mexico.
3. 1991 for Germany.
4. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.7. **Trend GDP growth in the OECD area, by sub-period, business sector**

Percentage change at annual rate

Business sector	1970[1]-00[2]	1970[1]-80	1980-90	1990[3]-00[2]	1996-00[2]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	3.4	3.2	3.3	3.6	4.1	2.8	2.8	2.9	3.1	3.4	3.6	3.9	4.1	4.1	4.2	4.1
Japan	3.6	4.8	4.1	1.7	1.0	4.0	3.4	2.7	2.2	1.8	1.5	1.3	1.1	1.0	1.0	..
Germany	..	..	..	1.8	2.1	..	..	1.5	1.5	1.8	1.7	1.8	1.9	2.0	2.1	2.2
western Germany	2.7	2.7	2.3	..	..	3.4	..		..	..	..	..	..	..	..	..
France	2.6	3.5	2.3	2.1	2.8	2.3	2.0	1.7	1.6	1.6	1.8	2.0	2.3	2.5	2.7	2.8
Italy	2.7	3.7	2.5	1.9	2.1	2.2	1.9	1.7	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.2
United Kingdom	2.4	2.0	3.1	2.0	2.8	2.1	1.8	1.4	1.4	1.7	2.0	2.3	2.6	2.7	2.7	..
Canada	3.3	4.1	2.7	3.1	4.0	1.8	1.7	1.8	2.2	2.7	3.1	3.5	3.8	4.1	4.1	4.1
Australia	3.6	2.9	3.5	4.1	4.5	3.3	3.3	3.4	3.7	4.0	4.3	4.5	4.6	4.5	4.4	4.3
Austria	2.9	3.6	2.4	2.7	2.6	3.2	3.1	2.9	2.7	2.6	2.5	2.6	2.6	..	..	..
Belgium	2.4	2.8	2.3	2.1	2.2	2.7	2.4	2.1	2.0	1.9	2.0	2.1	2.2	..	..	..
Denmark	2.0	1.3	2.2	2.6	3.1	1.5	1.8	1.8	2.1	2.5	2.8	3.0	3.1	3.1	3.1	..
Finland	2.8	2.8	2.6	2.9	4.9	0.6	0.2	0.3	1.0	1.9	2.9	3.8	4.5	4.9	5.0	4.9
Greece	2.2	3.9	0.7	2.1	2.8	1.3	1.4	1.5	1.6	1.8	2.1	2.4	2.7	2.9	2.9	..
Iceland	3.7	5.9	2.8	2.0	3.3	1.1	0.8	0.8	1.2	1.7	2.3	2.8	3.2	3.3	..	..
Ireland	5.2	4.7	4.0	7.4	8.7	5.6	5.7	6.0	6.5	7.1	7.8	8.4	8.7	8.8	..	..
Korea	7.7	7.5	9.2	6.1	4.1	8.9	8.3	7.8	7.2	6.6	5.9	5.1	4.4	3.9	..	..
Luxembourg	..	..	..	8.2	6.4	..	6.0	6.0	6.0	6.0	8.1	6.2	8.3	6.4	6.4	..
Mexico	..	..	1.3	2.5	..	2.9	3.0	2.9	2.6	2.3	2.2	2.2	..	..	..	..
Netherlands	2.7	2.8	2.2	3.1	3.4	3.1	3.0	2.9	2.9	2.9	3.1	3.2	3.3	3.4	..	..
New Zealand	2.2	2.2	1.3	2.9	3.3	1.2	1.6	2.2	2.8	3.3	3.5	3.5	3.3	..	..	..
Norway[4]	2.6	3.8	1.4	2.5	2.9	0.6	1.0	1.5	2.1	2.6	2.9	3.1	3.1	3.0	2.8	2.6
Portugal	3.2	4.2	2.8	2.1	..	3.3	2.7	2.2	1.9	1.8	1.8	..	..	..	..	..
Spain	2.8	3.2	2.4	2.9	3.5	3.1	2.7	2.4	2.3	2.4	2.6	2.9	3.2	3.5	3.6	3.6
Sweden	2.0	1.4	2.1	2.4	3.4	1.4	1.1	1.1	1.3	1.8	2.3	2.7	3.1	3.4	3.5	3.5
Switzerland	1.2	1.1	1.7	0.5	..	1.3	1.0	0.7	0.4	0.3	0.3	0.3	..	..	..	..
Turkey	4.6	3.4	5.5	5.0	..	9.8	0.7	6.2	8.3	..	..	..	..	..	..	..
Coefficient of variation																
OECD total[5]	0.42	0.42	0.59	0.52	0.46											
EU 15	0.28	0.33	0.29	0.55	0.52											
OECD 24[6]	0.30	0.36	0.39	0.51	0.47											

1. 1971 for Denmark, 1972 for Turkey, 1975 for Australia and Korea.
2. 1993 for Turkey, 1995 for Portugal, 1996 for Mexico and Switzerland, 1997 for Austria, Belgium and New Zealand, 1998 for Iceland, Ireland, Korea and Netherlands, 1999 for Japan, United Kingdom, Denmark, Greece and Luxembourg.
3. 1991 for Germany and Luxembourg.
4. Mainland only.
5. Excluding Czech Republic, Hungary and Poland.
6. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.8. Trend GDP per person employed in the OECD area, by sub-period, business sector

Percentage change at annual rate

Business sector	1970[1]-00[2]	1970[1]-80	1980[3]-90	1990[4]-00[2]	1996-00[2]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	1.3	1.1	1.3	1.7	1.9	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.0
Japan	2.7	4.0	2.8	1.3	1.0	2.5	2.1	1.7	1.4	1.2	1.1	1.0	1.0	1.0	1.0	..
Germany	..	..	..	1.5	1.3	..	..	1.8	1.7	1.7	1.6	1.4	1.3	1.3	1.2	1.2
western Germany	1.5	3.0	1.8	..	..	2.1	..	..	..	..	..	..	..	..	..	..
France	2.5	3.4	2.5	1.6	1.4	2.3	2.1	1.9	1.8	1.8	1.5	1.5	1.4	1.4	1.4	1.4
Italy	2.3	3.1	2.0	1.8	1.5	2.2	2.1	2.1	2.1	2.1	2.0	1.8	1.7	1.5	1.4	1.4
United Kingdom	1.9	2.5	1.9	1.2	1.2	1.0	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	..
Canada	1.2	1.1	1.1	1.5	1.7	1.1	1.1	1.3	1.4	1.5	1.5	1.8	1.6	1.7	1.7	1.7
Australia	1.8	1.9	1.3	2.1	2.2	1.3	1.5	1.8	2.0	2.2	2.2	2.3	2.3	2.3	2.1	2.0
Austria	2.8	3.4	2.5	2.5	2.5	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	..	..	..
Belgium	2.5	3.4	2.3	1.6	1.5	2.0	1.8	1.7	1.6	1.6	1.6	1.5	1.5	..	..	..
Denmark	2.0	2.4	1.4	2.4	2.4	1.5	1.8	2.2	2.5	2.6	2.6	2.8	2.5	2.4	2.4	..
Finland	3.4	3.3	3.4	3.6	3.3	3.6	3.7	3.8	4.0	4.0	3.8	3.6	3.5	3.3	3.2	3.2
Greece	1.7	3.5	0.2	1.5	2.1	1.1	1.1	1.0	1.0	1.2	1.4	1.7	2.0	2.1	2.2	..
Iceland	2.3	3.6	1.8	1.6	1.5	1.9	1.7	1.6	1.6	1.6	1.6	1.8	1.5	1.4	..	..
Ireland	4.0	4.6	3.9	3.5	3.1	4.1	3.9	3.7	3.5	3.5	3.5	3.4	3.2	3.0	..	..
Korea	5.3	4.8	6.3	4.4	3.5	5.6	5.3	5.1	4.8	4.6	4.3	4.0	3.6	3.4	..	..
Luxembourg	..	..	..	2.6	2.5	..	2.6	2.7	2.7	2.7	2.7	2.7	2.6	2.5	2.5	..
Mexico	..	..	–0.4	–0.8	..	0.2	0.0	–0.3	–0.6	–1.0	–1.3	–1.4	..	..	..	..
Netherlands	2.0	3.1	1.5	1.2	1.0	1.4	1.4	1.3	1.3	1.3	1.2	1.1	1.0	1.0	..	..
New Zealand	0.9	0.8	1.3	0.7	0.8	0.9	0.8	0.7	0.6	0.6	0.6	0.7	0.8	..	..	..
Norway[5]	2.1	3.0	1.4	1.9	1.5	2.1	2.3	2.5	2.4	2.2	1.9	1.7	1.6	1.5	1.5	1.5
Portugal	2.3	2.9	2.0	2.0	..	2.3	2.0	1.9	1.9	2.0	2.0	..	..	..	..	..
Spain	2.8	4.0	2.7	1.8	1.2	2.4	2.5	2.5	2.4	2.3	2.0	1.7	1.4	1.2	1.1	1.1
Sweden	2.2	1.9	2.0	2.7	2.4	2.2	2.5	2.8	3.1	3.2	3.1	3.0	2.7	2.5	2.3	2.2
Switzerland	0.2	0.5	0.1	0.1	..	–0.2	–0.2	0.0	0.1	0.2	0.2	0.2	..	..	..	..
Turkey	3.2	1.8	3.9	4.9	..	8.7	0.1	6.1	8.7	..	..	..	..	..	..	..
Coefficient of variation																
EU 15	0.3	0.2	0.4	0.4	0.4											
OECD 24[6]	0.4	0.4	0.5	0.5	0.4											

1. 1971 for Denmark, 1972 for Turkey, 1975 for Australia and Korea.
2. 1993 for Turkey, 1995 for Portugal, 1996 for Mexico and Switzerland, 1997 for Austria, Belgium and New Zealand, 1998 for Iceland, Ireland, Korea and Netherlands, 1999 for Japan, United Kingdom, Denmark, Greece and Luxembourg.
3. 1983 for Mexico.
4. 1991 for Germany.
5. Mainland only.
6. Excluding Czech Republic, Hungary, Korea, Mexico and Poland.

Source: *OECD Economic Outlook*, No. 70.

Table A1.9. Sensitivity analysis: MFP growth estimates (adjusted for hours worked), 1980-2000

Average annual growth rates

		1980-1990[1]	1990-2000[2]	1996-2000[3]
United States	Average factor shares (actual series)	1.05	1.20	1.53
	Average factor shares (trend series)	0.91	1.14	1.36
	Time-varing factor shares (trend series)	0.92	1.13	1.34
Japan	Average factor shares (actual series)	2.14	0.82	0.32
	Average factor shares (trend series)	2.03	1.17	0.86
	Time-varing factor shares (trend series)	2.15	1.02	0.71
Germany[4]	Average factor shares (actual series)	1.50	0.75	0.63
	Average factor shares (trend series)	1.45	0.96	0.86
	Time-varing factor shares (trend series)	1.49	0.94	0.81
France	Average factor shares (actual series)	1.92	1.02	1.53
	Average factor shares (trend series)	1.71	1.10	1.21
	Time-varing factor shares (trend series)	1.86	1.00	1.13
Italy	Average factor shares (actual series)	1.29	1.02	0.50
	Average factor shares (trend series)	1.50	1.10	0.87
	Time-varing factor shares (trend series)	1.55	1.03	0.75
United Kingdom	Average factor shares (actual series)	2.30	0.74	..
	Average factor shares (trend series)	2.00	0.73	..
	Time-varing factor shares (trend series)	..	0.74	..
Canada	Average factor shares (actual series)	0.76	1.34	1.96
	Average factor shares (trend series)	0.65	1.29	1.68
	Time-varing factor shares (trend series)	0.63	1.30	1.66
Australia	Average factor shares (actual series)	0.35	1.68	1.94
	Average factor shares (trend series)	0.53	1.34	1.46
	Time-varing factor shares (trend series)	0.57	1.31	1.43
Austria	Average factor shares (actual series)	2.09	1.39	..
	Average factor shares (trend series)	1.78	1.67	..
	Time-varing factor shares (trend series)	1.82	1.56	..
Belgium	Average factor shares (actual series)	1.79	1.19	..
	Average factor shares (trend series)	1.74	1.28	..
	Time-varing factor shares (trend series)	1.72	1.24	..
Denmark	Average factor shares (actual series)	1.25	1.44	0.93
	Average factor shares (trend series)	0.98	1.47	1.49
	Time-varing factor shares (trend series)	1.00	1.45	1.45
Finland	Average factor shares (actual series)	2.39	2.94	3.86
	Average factor shares (trend series)	2.29	3.10	3.54
	Time-varing factor shares (trend series)	2.38	3.16	3.60
Greece	Average factor shares (actual series)	1.68	0.71	1.72
	Average factor shares (trend series)	0.59	0.91	1.04
	Time-varing factor shares (trend series)	0.64	0.84	0.92
Iceland	Average factor shares (actual series)	..	1.48	..
	Average factor shares (trend series)	..	1.15	..
	Time-varing factor shares (trend series)	..	1.20	..

Table A1.9. **Sensitivity analysis: MFP growth estimates (adjusted for hours worked), 1980-2000** *(cont.)*

Average annual growth rates

		1980-1990[1]	1990-2000[2]	1996-2000[3]
Ireland	Average factor shares (actual series)	4.15	3.72	. .
	Average factor shares (trend series)	3.55	4.39	. .
	Time-varing factor shares (trend series)	3.60	4.41	. .
Netherlands	Average factor shares (actual series)	2.29	1.45	. .
	Average factor shares (trend series)	2.21	1.60	. .
	Time-varing factor shares (trend series)	2.26	1.58	. .
New Zealand	Average factor shares (actual series)	0.09	0.79	. .
	Average factor shares (trend series)	0.17	0.75	. .
	Time-varing factor shares (trend series)	0.20	0.76	. .
Norway	Average factor shares (actual series)	0.82	1.83	0.96
	Average factor shares (trend series)	1.11	1.79	1.39
	Time-varing factor shares (trend series)	1.19	1.74	1.34
Spain	Average factor shares (actual series)	2.07	0.81	0.43
	Average factor shares (trend series)	1.90	0.81	0.56
	Time-varing factor shares (trend series)	2.06	0.72	0.49
Sweden	Average factor shares (actual series)	1.02	1.38	. .
	Average factor shares (trend series)	1.01	1.44	. .
	Time-varing factor shares (trend series)	1.03	1.42	. .
Switzerland	Average factor shares (actual series)	. .	–0.15	. .
	Average factor shares (trend series)	. .	–0.49	. .
	Time-varing factor shares (trend series)	. .	–0.41	. .

1. 1983-1990 for Belgium, Denmark, Greece and Ireland, 1985-1990 for Austria and New Zealand.
2. 1991-1996 for Switzerland, 1991-1998 for Iceland, 1991-2000 for Germany, 1990-1996 for Ireland and Sweden, 1990-1997 for Austria, Belgium, New Zealand and United Kingdom, 1990-1998 for Netherlands, 1990-1999 for Australia, Denmark, France, Greece, Italy and Japan.
3. 1996-1999 for Australia, Denmark, France, Greece, Italy and Japan.
4. Western Germany for 1980-1990.

Source: OECD.

Notes

1. For a fuller description, see Bassanini *et al.*, (2000); Colecchia and Schreyer (2002).
2. It should also be stressed that aggregation through (however defined) user costs assumes that assets are homogeneous. This implies that different vintages of the same machine should be counted as different assets, while their current prices (expressed in terms of the output deflator) appear in equation [A.1.4]. In practice, however, this would introduce unsolvable problems in the construction of growth rates for new machines. As a solution, Jorgenson and Griliches (1967) suggest extending the foregoing procedure to aggregate different vintages of the same asset through the use of hedonic price indexes. In this way the aggregate flow of capital services of each asset across all vintages can be seen as proportional to the existing stock of that capital asset expressed in efficiency units.
3. Scarpetta *et al.* (2000) also compare trend series obtained with this approach with those obtained extending the time series by means of the OECD Medium Term Reference Scenario (MTRS). The results are broadly similar, although in a few instances estimated growth rates for the most recent years show some differences. Amongst the G-7 countries, trend GDP growth rates for Japan in 2000 will be somewhat lower using MTRS, while significant differences for 1999 and 2000 are also found for Ireland, Korea, Mexico and Turkey (with lower GDP growth rates obtained by using MTRS) as well as Greece (with higher GDP growth rate obtained by using MTRS).
4. The use of both is not frequent in the literature: the Phillips curve has been used more widely (*e.g.* Gordon, 1997, and OECD, 1999a, 1999b), however Okun's law has been used by Moosa (1997). Laxton and Tetlow (1992), Conway and Hunt (1997) and Apel and Jansson (1999) use both.

Annex 2

The policy-and-institutions augmented growth model

Following a standard approach (see *e.g.* Mankiw *et al.*, 1992; and Barro and Sala-i-Martin, 1995), the standard neoclassical growth model is derived from a constant returns to scale production function with two inputs (capital and labour) that are paid their marginal products. Production at time t is given by:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} \left(A(t)L(t)\right)^{1-\alpha-\beta} \qquad \text{[A2.1]}$$

where Y, K, H and L are respectively output, physical capital, human capital and labour, α is the partial elasticity of output with respect to physical capital, β is the partial elasticity of output with respect to human capital and A(t) is the level of technological and economic efficiency. It can be assumed that the level of economic and technological efficiency A(t) has two components: economic efficiency $I(t)$ dependent on institutions and economic policy (a vector $V(t)$) and the level of technological progress $\Omega(t)$ (see amongst others, Cellini *et al.*, 1999 for a similar formulation). In turn, $I(t)$ can be written as, *e.g.* a log-linear function of institutional and policy variables, while $\Omega(t)$ is assumed to grow at the rate $g(t)$.

The time paths of the right-hand side variables are described by the following equations (hereafter dotted variables represent derivatives with respect to time):

$$\begin{aligned}
\dot{k}(t) &= s_k(t)A(t)^{1-\alpha-\beta}k(t)^{\alpha}h(t)^{\beta} - (n(t)+d)k(t) \\
\dot{h}(t) &= s_h(t)A(t)^{1-\alpha-\beta}k(t)^{\alpha}h(t)^{\beta} - (n(t)+d)h(t) \\
A(t) &= I(t)\Omega(t) \\
\ln I(t) &= p_0 + \textstyle\sum_j p_j \ln V_j(t) \\
\dot{\Omega}(t) &= g(t)\Omega(t) \\
\dot{L}(t) &= n(t)L(t)
\end{aligned} \qquad \text{[A2.2]}$$

where $k = K/L$, $h = H/L$, $y = Y/L$, stand for the capital labour ratio, average human capital and output per worker respectively; s_k and s_h stand for the investment rate in physical and human capital respectively; d stands for the (constant) depreciation rate; and n is the growth rate of the population. Under the assumption that $\alpha + \beta < 1$ (*i.e.* decreasing returns to reproducible factors), this

system of equations can be solved to obtain steady-state values of k^* and h^* defined by:

$$\ln k^*(t) = \ln A(t) + \frac{1-\beta}{1-\alpha-\beta}\ln s_k(t) + \frac{\beta}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha-\beta}\ln(g(t)+n(t)+d)$$
$$\ln h^*(t) = \ln A(t) + \frac{\alpha}{1-\alpha-\beta}\ln s_k(t) + \frac{1-\alpha}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha-\beta}\ln(g(t)+n(t)+d) \qquad \text{[A2.3]}$$

Substituting these two equations into the production function and taking logs yields the expression for the steady-state output in intensive form. The latter can be expressed either as a function of s_h (investment in human capital) and the other variables or as a function of h^* (the steady-state stock of human capital) and the other variables. Since in Chapter 2 human capital is proxied by the average years of education of the working age population, a formulation in terms of the stock of human capital was retained. The steady-state path of output in intensive form can be written as:*

$$\ln y^*(t) = \ln\Omega(t) + p_0 + \sum_j p_j \ln V_j(t)$$
$$+ \frac{\alpha}{1-\alpha}\ln s_k(t) + \frac{\beta}{1-\alpha}\ln h^*(t) - \frac{\alpha}{1-\alpha}\ln(g(t)+n(t)+d) \qquad \text{[A2.4]}$$

However, the steady-state stock of human capital is not observed. As shown by Bassanini and Scarpetta (2002), the expression for h^* as a function of actual human capital is:

$$\ln h^*(t) = \ln h(t) + \frac{1-\psi}{\psi}\Delta\ln(h(t)/A(t)) \qquad \text{[A2.5]}$$

where ψ is a function of (α,β) and $n + g + d$.

Equation [A2.4] would be a valid specification in the empirical cross-country analysis if countries were in their steady states or if deviations from the steady state were independent and identically distributed. If observed growth rates include out-of-steady-state dynamics, then the transitional dynamics have to be modelled explicitly. A linear approximation of the transitional dynamics can be expressed as follows (Mankiw *et al.*, 1992):

$$\Delta\ln y(t) = -\phi(\lambda)\ln(y(t-1)) + \phi(\lambda)\frac{\alpha}{1-\alpha}\ln s_k(t) + \phi(\lambda)\frac{\beta}{1-\alpha}\ln h(t) + \sum_j p_j\phi(\lambda)\ln V_j(t)$$
$$+ \frac{1-\psi}{\psi}\frac{\beta}{1-\alpha}\Delta\ln h(t) - \phi(\lambda)\frac{\alpha}{1-\alpha}\ln(g(t)+n(t)+d) + \left(1-\frac{\phi(\lambda)}{\psi}\right)g(t) + \phi(\lambda)(p_0 + \ln\Omega(0)) + \phi(\lambda)g(t)t \qquad \text{[A2.6]}$$

* Strictly speaking, equation [A2.4] is written under the simplifying assumption that policy and institutional variables do not change persistently in the long-run. If this is not the case, $\ln(g+n+d)$ must be augmented by a term reflecting the rate of change of policy and institutional variables. As the estimable equation is linearised and contains short-run dynamics anyway, this term will be omitted hereafter for simplicity.

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where $\lambda = (1-\alpha-\beta)(g(t)+n(t)+d)$. Adding short-term dynamics to equation [A2.6] yields:

$$\Delta \ln y(t) = a_0 - \phi \ln y(t-1) + a_1 \ln s_k(t) + a_2 \ln h(t) - a_3 n(t) + a_4 t + \sum_j a_{j+4} \ln V_j \\ + b_1 \Delta \ln s_k(t) + b_2 \Delta \ln h(t) + b_3 \Delta \ln n(t) + \sum_j b_{j+4} \Delta \ln V_j + \varepsilon(t) \quad \text{[A2.7]}$$

Equation [A2.7] represents the generic functional form that has been empirically estimated in Chapter 2. Estimates of steady state coefficients as well as of the parameters of the production function can be retrieved on the basis of the estimated coefficients of this equation by comparing it with equation [A2.6]. For instance, an estimate of the elasticity of steady state output to the investment rate (that is the long-run effect of the investment rate on output) is given by $\hat{a}_1 / \hat{\phi}$, where ^ identifies estimated coefficients. Conversely, an estimate of the share of physical capital in output (the parameter α of the production function) can be obtained as $\hat{a}_1 / (\hat{\phi} + \hat{a}_1)$.

Annex 3

Methodological details on the empirical analysis of industry multi-factor productivity[1]

A3.1. The theoretical framework

The basic framework of the analysis starts with a standard production function (in country i and sector j), under perfect competition and constant returns to scale. This can be formalised as follows:

$$Y_{ijt} = A_{ijt} \cdot F_{ij}\left(L_{ijt}, K_{ijt}\right)$$

where Y is output,[2] A is a Hicks-neutral parameter of technical change,[3] F_{ij} is a country/sector-specific production function, K is physical capital and L labour. Assuming a Cobb-Douglas production function and taking logs yield:

$$y_{ijt} = a_{ijt} + \alpha_{ijt} \cdot l_{ijt} + \left(1 - \alpha_{ijt}\right) k_{ijt}$$

In this context, multi-factor productivity growth can be proxied by the so called Solow residual as follows:

$$\Delta MFP_{ijt} = \Delta y_{ijt} - \alpha_{ijt} \cdot \Delta l_{ijt} - \left(1 - \alpha_{ijt}\right) \Delta k_{ijt}$$

The convergence equation

In order to assess the driving forces of MFP growth, the models adopts a catch-up specification, whereby, within each industry, the production possibility set is influenced by technological and organisational transfer from the technology-frontier country to other countries. The co-integration model of MFP may also account for the international transmission of business cycles across OECD countries (for instance trade and financial channels). In this context, multi-factor productivity for a given industry j of country i at date t (MFP_{ijt}) can be modelled as an auto-regressive distributed lag ADL(1,1) process in which the level of MFP is co-integrated with the level of MFP of the technological frontier country F. Formally:

$$\ln MFP_{ijt} = \beta_1 \ln MFP_{ijt-1} + \beta_2 \ln MFP_{Fjt} + \beta_3 \ln MFP_{Fjt-1} + \omega_{ijt} \qquad [A3.1]$$

where ω stands for all observable and non-observable factors influencing the level of MFP. Under the assumption of long-run homogeneity ($1 - \beta_1 = \beta_2 + \beta_3$) and rearranging equation [A3.1] yields the convergence equation:

$$\Delta \ln MFP_{ijt} = \beta_2 \Delta \ln MFP_{Fjt} - (1-\beta_1) RMFP_{ijt} + \omega_{ijt} \qquad \text{[A3.2]}$$

where $RMFP_{ijt} = ln(MFP_{ijt}) - ln(MFP_{Fjt})$ is the technological gap between country i and the leading country F. This is the specification used in the empirical analysis. Moreover, the following (productivity) index is used as a measure of the MFP level:

$$MFP_{ijt} = \frac{Y_{ijt}}{\overline{Y}_{jt}} \cdot \left(\frac{\overline{L}_{jt}}{L_{ijt}}\right)^{\alpha_{ijt}} \cdot \left(\frac{\overline{K}_{jt}}{K_{ijt}}\right)^{1-\alpha_{ijt}} \qquad \text{[A3.3]}$$

where a *bar* denotes a geometric average over all the countries for a given industry j and year t. The index has the desirable properties of superlativeness and transitiveness which makes it possible to compare national productivity levels (see Caves *et al.*, 1982). However, the comparison of productivity levels also requires the conversion of underlying data into a common currency, while also taking into account differences in purchasing powers across countries. These issues are discussed in the next section.

The residual in equation [A3.2] is modelled as follows:

$$\omega_{ijt} = \sum_k \gamma_k V_{kijt-1} + f_i + g_j + d_t + \varepsilon_{ijt} \qquad \text{[A3.4]}$$

where (V_{ijt}) is a vector of covariates (*e.g.* product and labour market regulations, human capital, or R&D) affecting the level of MFP; f_i, g_j, and d_t are respectively country, industry and year fixed effects. ε is an *2d* shock. Moreover, equation [A3.2] can be solved for steady-state MFP in country i relative to the frontier in industry j which gives insights on the effects of these country and/or country-industry specific factors on the steady-state level of MFP.

The steady-state equilibrium

At a steady-state equilibrium, the independent variables are constant over time ($\omega_{ijt} = \omega_{ij}$) and the multi-factor productivity in sector j grows at the same constant rate in all countries: $\Delta lnMFP_{ijt} = \Delta lnMFP_{Fj}$.

For the ease of exposition, the residual in equation [A3.2] is redefined as follows:

$$\omega_{ijt} = \omega'_{ijt} + \omega''_{ijt} \cdot RMFP_{ijt} \qquad \text{[A3.5]}$$

where ω' and ω'' correspond to the factors affecting the rate of growth of MFP respectively, directly or through the diffusion of technology and organisational

practises. Solving for the steady-state, one can obtain the following expression for the level of *MFP* in country *i* relative to the frontier in industry *j*:

$$RMFP_{ij} = \frac{\omega'_{ij} - (1-\beta_2)\Delta MFP_{Fj}}{(1-\beta_1) - \omega''_{ij}} \qquad \text{[A3.6]}$$

Notes

1. For details on the method of estimation (approach followed, diagnostic tests, sensitivity analysis, etc.) see Scarpetta and Tressel (2002).
2. The analysis follows a value-added concept of output, which does not require measures of intermediate consumption. This is the proper approach because the industries that we use may have different levels of aggregation.
3. Technical change is "Hicks neutral", or "output augmenting", when it can be represented as an outward shift of the production function that affects all factors of production in the same proportion.

Annex 4

Details on firm-level data

A4.1. The data and indicators of firm dynamics and survival

Raw data on firm dynamics and survival

The analysis of firm entry and exit and firm survival presented in Chapter 4 is based on business registers (Canada, Denmark, France, Finland, Netherlands, United Kingdom and United States) or social security databases (Germany and Italy). Data for Portugal are drawn from an employee-based register containing information on both establishments and firms.

The key features of these data on firm dynamics and survival are as follows:

Unit of observation: Data used in the study refer to the firm as the unit of reference, with the exception of Germany where data are only available with reference to establishments. More specifically, most of the data used conform to the following definition (Eurostat, 1995) "*an organisational unit producing goods or services which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources*". Generally, this will be above the establishment level. However, firms that have operating units in multiple countries in the EU will have at least one unit counted in each country. Of course, it may well be that the national boundaries that generate a statistical split-up of a firm, in fact split a firm in a "real" sense as well. Also related to the unit of analysis is the issue of mergers and acquisitions. Only in some countries does the business register keep close track of such organisational changes within and between firms. In addition, ownership structures themselves may vary across countries because of tax considerations or other factors that influence how business activities are organised within the structure of defined legal entities.

Size threshold: While some registers include even single-person businesses, others omit firms smaller than a certain size, usually in terms of the number of employees, but sometimes in terms of other measures such as sales (as is the case in the data for France and Italy). Data used in this study exclude single-person businesses. However, because smaller firms tend to have more volatile firm dynamics, remaining differences in the threshold

across different country datasets should be taken into account in the international comparison.

Period of analysis: Data on firm dynamics and survival are compiled on an annual basis, covering varying time spans. The German, Danish and Finnish register data cover the longest time periods, while data for the other countries are available for shorter periods of time or, although available for longer periods, include significant breaks in definitions or coverage. In most of the analysis presented in Chapter 4, data refer to the period 1989-94, which guarantees the largest country coverage.

Sectoral coverage: Special efforts have been made to organise the data in a common industry classification (ISIC Rev.3, see Table A4.1) that matches the OECD STAN database. In the panel data constructed to generate the tabulations, firms were allocated to the STAN industry that most closely fitted their operations over the complete time-span. Note that in countries where the data collection by the statistical agency varied across major sectors (*e.g.*, construction, industry, services), a firm that switched between major sectors could not be tracked as a continuing firm, but ended up creating an exit in one sector and an entry in another. Most countries have been able to provide firm demographic data across most sectors of the economy, with the exception that public services are often not included (the United Kingdom is a special case, where data only refer only to manufacturing).

Indicators collected for firm dynamics and survival

The use of annual data on firm dynamics implies a significant volatility in the resulting indicators. In order to limit the possible impact of measurement problems, it was decided to use definitions of continuing, entering and exiting firms on the basis of three (rather than the usual two) time periods. Thus, the tabulations of firm dynamics contained the following variables:

- Firm entry, comprising firms observed as (out, in, in) the register in time (t – 1, t, t + 1).
- Firm exit, comprising firms observed as (in, in, out) the register in time (t – 1, t, t + 1).
- Continuing firms, comprising firms observed as (in, in, in) the register in time (t – 1, t, t + 1).
- One-year firms, comprising firms observed as (in, out, in) the register in time (t – 1, t, t + 1).

Table A4.1. **The STAN industry list (based on ISIC Rev. 3)**

ISIC Rev. 3 codes	Industry name
Total	Total
01-05	Agriculture, hunting, forestry and fishing
10-14	Mining and quarrying
15-37	Total manufacturing
15-16	Food products, beverages and tobacco
17-19	Textiles, textile products, leather and footwear
20	Wood, products of wood and cork
21-22	Pulp paper, paper products, printing and publishing
23-25	Chemical rubber plastics and fuel products
23-24	Chemical and fuel products
23	Coke refined petroleum products and nuclear fuel
24	Chemicals and chemical products
24 ex 2423	Chemicals excluding pharmaceuticals
2 423	Pharmaceuticals
25	Rubber and plastics products
26	Other non-metallic mineral products
27-35	Basic metals, metal products, machinery and equipment
27-33	Basic metals, metal products, machinery and equipment, excluding transport
27-28	Basic metals and fabricated metal products
27	Basic metals
28	Fabricated metal products except machinery and equipment
29-33	Machinery and equipment
29	Machinery and equipment n.e.c.
30-33	Electrical and optical equipment
30	Office accounting and computing
31	Electrical machinery and apparatus nec
32	Radio, television and communication equipment
33	Medical precision and optical instruments
34-35	Transport equipment
34	Motor vehicles trailers and semi-trailers
35	Other transport equipment
351	Building and repairing of ships and boats
353	Aircraft and spacecraft
352+359	Railroad equipment and transport
36-37	Manufacturing nec; recycling
40-41	Electricity gas and water supply
45	Construction
50-99	Total services
50-74	Business sector services
50-55	Wholesale and retail trade; restaurants and hotels
50-52	Wholesale and retail trade; repairs
55	Hotels and restaurants
60-64	Transport and storage and communication
60-63	Transport and storage

Table A4.1. **The STAN industry list (based on ISIC Rev. 3)** *(cont.)*

ISIC Rev. 3 codes	Industry name
64	Post and telecommunications
65-74	Finance insurance real estate and business services
65-67	Financial intermediation
65	Financial intermediation except insurance and pension funding
66	Insurance and pension funding except compulsory social security
67	Activities related to financial intermediation
70-74	Real estate renting and business activities
70	Real estate activities
71	Renting of machinery and equipment
72	Computer and related activities
73	Research and development
74	Other business activities
75-99	Community social and personal services
75	Public admin. and defence; compulsory social security
80	Education
85	Health and social work
90-93	Other community social and personal services
95	Private households with employed persons
99	Extra-territorial organisations and bodies

Source: OECD.

This method of defining continuing, entering and exiting firms implies that a change in the stock of continuing firms (C) relates to entry (E) and exit (X) in the following way:

$$C_t - C_{t-1} = E_{t-1} - X_t \quad [A4.1]$$

This has implications for the appropriate measure of firm "turnover". Given that continuing, entering, exiting and "one-year" firms (O) all exist in time t then the total number of firms (T) is:

$$T_t = C_t + E_t + X_t + O_t \quad [A4.2]$$

From this, the change in the total number of firms between two years, taking into account equation A4.1, can be written as:

$$T_t - T_{t-1} = E_t - X_{t-1} + O_t - O_{t-1} \quad [A4.3]$$

Thus, a turnover measure that is consistent with the contribution of net entry to changes in the total number of firms should be based on the sum of contemporaneous entry with lagged exit.

In practice, a number of complications arise in constructing and interpreting data that conform to the definitions of continuing, entering and exiting firms described above. In particular, the "one-year" category, in

principle, represents short-lived firms that are observed in time t but not in adjacent time periods and could therefore be treated as an additional piece of information in evaluating firm demographics. However, in some databases this category also includes measurement errors and possibly ill-defined data. Thus, the total number of firms in the analysis for the main text excludes these "one-year" firms.

Available data also allowed to track entering firms over time and to assess the contribution of firm dynamics to the overall job turnover by industry and over time. In particular, the following indicators were constructed:

- **The analysis of survival:** Entering cohorts of firms were tracked down which allowed assessment of the probability of failure and survivor rates by duration. Moreover, information was collected on employment in these firms, both in the year of entry and in subsequent years.
- **Job creation and destruction:** Additional information on employment changes in continuing firms also permitted the calculation of the overall job turnover by industry and over time and assessment of the contribution of firm dynamics to this process.[1]

A4.2. Productivity decomposition data

Using mainly longitudinal business surveys, Chapter 4 provides a decomposition of industry productivity growth into the contribution of within-firm growth and that due to reallocation of resources across firms – which includes reallocation amongst incumbents, as well as reallocation due to the entry of new units and/or the exit of other units. Detailed results are presented in Tables A4.2 to A4.8 at the end of this Annex. They are based on the approach developed by Griliches and Regev (1995) (referred to hereafter as the GR method), but alternative calculations were also made in order to check the robustness of the results, based on the method developed by Foster, Haltiwanger, and Krizan (1998) (referred hereafter as the FHK method). This section of the Annex aims to provide methodological details on both approaches. Full details on their results can be found in Scarpetta *et al.* (2002).

Definition of entry and exit

Following standard practice, the productivity decompositions were based on a fairly long time interval (in this case 5 years). Thus, unlike the annual firm-demographics data, a more conventional method of defining continuing, entering and exiting firms was used:

- Continuing firms: observed both in the first year (t – k) and the last year (t) of the period.

- Entering firms: observed in the last year (t), but not in the first year (t – k).
- Exiting firms: observed in the first year (t – k), but not in the last year (t).

Decomposition methods

The GR method can best be understood by examining first the FHK method, as it is essentially a simplification of the latter. The FHK method decomposes aggregate productivity growth into five components, commonly called the "within effect", "between effect", "cross effect", "entry effect", and "exit effect", as follows:

$$\Delta P_t = \sum_{i \in C} \theta_{it-k} \Delta p_{it} + \sum_{i \in C} \Delta \theta_{it} (p_{it-k} - P_{t-k}) + \sum_{i \in C} \Delta \theta_{it} \Delta p_{it} + \sum_{i \in N} \theta_{it} (p_{it} - P_{t-k}) - \sum_{i \in X} \theta_{it-k} (p_{it-k} - P_{t-k}) \qquad \text{[A4.4]}$$

where Δ means changes over the *k*-years' interval between the first year (t – *k*) and the last year (t); θ_{it} is the share of firm *i* in the given sector at time t; C, N, and X are sets of continuing, entering, and exiting firms, respectively; and P_{t-k} is the aggregate (*i.e.*, weighted average) productivity level of the sector as of the first year (t – *k*).[2]

Thus, the components of the FHK decomposition are defined as follows:

i) The *within-firm effect* is within-firm productivity growth weighted by initial output shares.

*ii)*The *between-firm effect* captures the gains in aggregate productivity coming from the expanding market of high productivity firms, or from low-productivity firms' shrinking shares weighted by *initial* shares.

iii) The "*cross effect*" reflects gains in productivity from high-productivity *growth* firms' expanding shares or from low-productivity *growth* firms' shrinking shares.

iv) The *entry effect* is the sum of the differences between each entering firm's productivity and *initial* productivity in the industry, weighted by its market share.

v) The *exit effect* is the sum of the differences between each exiting firm's productivity and *initial* productivity in the industry, weighted by its market share.

While the FHK method uses the first year's values for a continuing firm's share (θ_{it-k}), its productivity level (p_{it-k}) and the sector-wide average productivity level (P_{t-k}), the GR method uses the time averages of the first and last years for them ($\overline{\theta_i}$, $\overline{p_i}$, and $\overline{P}$). As a result the, "cross-effect" or

("covariance") term in the FHK method, disappears from the decomposition. The resulting formula is:

$$\Delta P_t = \sum_{i \in C} \overline{\theta}_i \Delta p_{it} + \sum_{i \in C} \Delta\theta_{it}(\overline{p_i} - \overline{P}) + \sum_{i \in N} \theta_{it}(p_{it} - \overline{P}) - \sum_{i \in X} \theta_{it-k}(p_{it-k} - \overline{P}) \qquad \text{[A4.5]}$$

where a *bar* over a variable indicates the average of the variable over the first year (t – *k*) and the last year (t). Thus, the components of the GR decomposition can be described as follows:

i) The *within effect* describes the productivity growth within firms weighted by the *average* firm share over the time interval of the calculation.

ii) The *between-firm effect* captures the gains in aggregate productivity which comes from high-productivity firms' expanding shares, or from low-productivity firms' shrinking shares weighted by *average* shares over the time interval of the calculation.

iii) The *entry effect* is the sum of the differences between each entering firm's productivity and *average* productivity in the industry, weighted by its market share.

iv) The *exit effect* is the sum of the differences between each exiting firm's productivity and *average* productivity in the industry, weighted by its market share.

Certain aspects of the decomposition need to be borne in mind when interpreting the data:

The FHK "within effect" reflects the pure contribution of continuing individual firms' productivity growth, as it is weighted by the *initial* shares. The "between effect" reflects the contribution of changes in market share, given initial productivity level and the "cross effect" or "covariance term" reveals whether firms with increasing productivity also tend to increase market share or not.

By contrast, in the GR method the distinction between the within and between effects is somewhat blurred in the sense that time averaging makes the within effect term affected by changes in the firms' shares over time and the between effect term affected by changes in productivity over time.

Although disadvantageous in some respects, it has been suggested that the GR method is less sensitive than the FHK method to annual fluctuations in the underlying data and, possibly, measurement errors. For example, firms with overestimated labour input in a given year will have spuriously low measured labour productivity and spuriously high measured employment share in that year, potentially producing negative covariance between

productivity and share changes. In this case, the within effect in the FHK method could be misleadingly high.[3]

Care has to be taken in interpreting the entry and exit components as they do not always reflect a comparison between productivity levels at the same point in time. For example, in the version of the FHK decomposition used in Chapter 4, the entry component comprises the difference between average productivity among entrants at the *end* of the 5-year period with overall productivity at the *beginning*. Obviously, therefore, a positive entry component does not necessarily mean that productivity among entering firms is above average in relation to their contemporaries.

Notes

1. It should be noted that the gross employment flows tabulated from the statistical register files do not necessarily coincide with gross job flow data tabulated from production surveys, such as those used by Davis *et al.* (1996).
2. The shares are usually based on employment in decompositions of labour productivity and on output in decompositions of total factor productivity.
3. Similarly, in the case of total factor productivity decomposition using output shares, random measurement errors in output could yield a positive covariance between productivity changes and share changes, and hence, the within effect could be spuriously low.

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Table A4.2. Labour productivity decompositions Finland, average period: 1987-1992

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition			of which	
		Within	Between	Net entry	Entry	Exit
Total manufacturing	5.0	2.6	0.9	1.5	0.0	1.5
Food products beverages and tobacco	4.4	3.4	0.1	1.0	0.3	0.7
Textiles textile products leather and footwear	3.1	0.0	0.8	2.3	0.1	2.2
Wood and products of wood and cork	4.8	3.5	0.3	1.0	0.2	0.8
Pulp paper paper products printing and publishing	4.9	3.1	0.7	1.0	–0.2	1.2
Chemical rubber plastics and fuel products	4.0	3.4	0.0	0.6	0.1	0.5
Chemical and fuel products	2.8	3.3	–1.2	0.7	0.3	0.5
Coke refined petroleum products and nuclear fuel	4.4	7.3	–0.9	. .	–2.0	. .
Chemicals and chemical products	3.2	2.7	–0.1	0.6	0.4	0.2
Chemicals excluding pharmaceuticals	3.2	2.5	–0.0	0.7	0.3	0.4
Pharmaceuticals	3.5	3.4	–0.2	0.3	0.6	–0.4
Rubber and plastics products	4.3	3.6	0.3	0.5	0.2	0.3
Other non-metallic mineral products	2.4	1.5	0.2	0.7	0.5	0.3
Basic metals metal products machinery and equipment	4.6	2.7	0.8	1.1	–0.0	1.1
Basic metals metal products machinery and equipment excl. transport	4.6	2.5	0.9	1.2	–0.0	1.2
Basic metals and fabricated metal products	4.9	2.8	1.2	1.0	–0.4	1.4
Basic metals	6.3	3.8	1.4	1.1	0.2	0.8
Fabricated metal products excl. machinery and equipment	2.7	2.0	0.1	0.6	–0.4	1.0
Machinery and equipment	4.4	2.4	0.8	1.2	0.2	1.1
Machinery and equipment n.e.c.	1.8	0.5	0.5	0.8	–0.1	0.9
Electrical and optical equipment	7.8	4.9	1.1	1.8	0.4	1.5
Office accounting and computing machinery	9.6	3.0	0.4	6.2	4.7	1.6
Electrical machinery and apparatus n.e.c.	7.5	4.0	0.8	2.7	0.8	1.9
Radio television and communication equipment	8.1	6.6	1.2	0.2	0.0	0.2
Medical precision and optical instruments	5.7	4.8	0.3	0.6	–0.1	0.7
Transport equipment	4.4	3.5	0.3	0.6	–0.2	0.8
Motor vehicles trailers and semi-trailers	3.4	1.6	0.5	1.3	–0.4	1.7
Other transport equipment	4.9	4.5	0.1	0.2	–0.0	0.3
Building and repairing of ships and boats	5.7	4.6	0.3	0.7	–0.2	0.9
Railroad equipment and transport equipment n.e.c.	2.1	4.2	–0.4	–1.7	0.6	–2.3
Manufacturing n.e.c.; recycling	3.3	2.0	0.3	1.0	0.3	0.7

Table A4.2. Labour productivity decompositions *(cont.)*
Finland, average period: 1989-1994

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	5.2	3.0	0.9	1.3	–0.1	1.4
Food products beverages and tobacco	5.0	3.8	0.4	0.8	0.2	0.6
Textiles textile products leather and footwear	5.8	2.5	0.8	2.5	0.2	2.3
Wood and products of wood and cork	4.7	3.7	0.0	1.0	0.2	0.9
Pulp paper paper products printing and publishing	6.0	3.8	1.0	1.2	–0.1	1.3
Chemical rubber plastics and fuel products	3.4	2.9	–0.2	0.7	0.1	0.6
Chemical and fuel products	3.2	2.8	–0.5	0.9	0.4	0.5
Coke refined petroleum products and nuclear fuel	6.4	6.5	–0.1	–0.0	–1.3	1.3
Chemicals and chemical products	2.4	2.4	–0.6	0.6	0.3	0.3
Chemicals excluding pharmaceuticals	4.0	3.7	–0.5	0.8	0.2	0.6
Pharmaceuticals	–3.1	–2.4	–0.4	–0.3	–0.0	–0.3
Rubber and plastics products	3.6	3.0	0.3	0.3	–0.1	0.4
Other non-metallic mineral products	2.2	1.8	–0.4	0.8	0.6	0.3
Basic metals metal products machinery and equipment	4.4	2.8	1.1	0.6	–0.4	1.0
Basic metals metal products machinery and equipment excl. transport	4.7	2.9	1.3	0.5	–0.5	1.0
Basic metals and fabricated metal products	4.5	2.6	1.2	0.7	–0.7	1.4
Basic metals	4.4	3.3	0.9	0.2	–0.2	0.4
Fabricated metal products excl. machinery and equipment	2.7	2.2	–0.2	0.6	–0.3	0.9
Machinery and equipment	4.9	3.0	1.4	0.5	–0.3	0.8
Machinery and equipment n.e.c.	1.7	0.7	0.6	0.4	–0.4	0.8
Electrical and optical equipment	8.5	5.8	2.1	0.6	–0.2	0.9
Office accounting and computing machinery	9.0	4.9	2.6	1.5	0.3	1.2
Electrical machinery and apparatus n.e.c.	5.6	3.8	1.1	0.7	–0.3	1.0
Radio television and communication equipment	12.2	9.4	1.4	1.3	–0.7	2.0
Medical precision and optical instruments	4.3	3.4	0.2	0.7	0.2	0.5
Transport equipment	2.4	1.7	–0.1	0.8	–0.1	0.9
Motor vehicles trailers and semi-trailers	–0.5	–0.4	–0.8	0.6	–0.2	0.8
Other transport equipment	4.2	2.8	0.5	1.0	0.1	0.9
Building and repairing of ships and boats	5.5	4.4	–0.0	1.1	–0.0	1.2
Railroad equipment and transport equipment n.e.c.	–1.0	–2.6	1.0	0.6	–0.1	0.7
Manufacturing n.e.c.; recycling	3.0	1.7	0.4	1.0	0.3	0.7

Source: OECD.

Table A4.3. **Labour productivity decompositions France, average period: 1987-1992**

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	2.3	2.0	0.0	0.2	–0 2	0.4
Food products beverages and tobacco	2.6	2 4	–0.3	0.4	0.2	0.2
Textiles textile products leather and footwear	1.8	1.5	0.3	–0.1	–0.8	0.7
Wood and products of wood and cork	1.9	1.6	0.6	–0.3	–0.1	–0.2
Pulp paper paper products printing and publishing	2.3	1.3	0.2	0.8	0.4	0.4
Chemical and fuel products	2.6	2.0	0.2	0.4	0.2	0.3
Coke refined petroleum products and nuclear fuel	–1.1	–0.9	–0.3	0.1	–0.1	0.2
Chemicals and chemical products	3.0	2 3	0.3	0.4	0.2	0.2
Chemicals excluding pharmaceuticals	2.3	1.9	0.1	0.4	0.3	0.1
Pharmaceuticals	4.2	3.0	0.7	0.5	0.1	0.4
Rubber and plastics products	2.4	1.7	0.5	0.2	0.3	–0.1
Other non-metallic mineral products	0.6	1.2	–0.4	–0.2	–0.1	–0.1
Basic metals metal products machinery and equipment excl. transport	1.3	2.0	–0.2	–0.4	–0.1	–0.3
Basic metals and fabricated metal products	–0.1	1.7	–0.4	–1.4	–0 4	–1.0
Machinery and equipment	2.4	2.2	–0.1	0.4	0.2	0.3
Machinery and equipment n.e.c.	2.4	2.1	–0.1	0.4	0.2	0.2
Electrical and optical equipment	2.5	2.3	–0.1	0.4	0.1	0.3
Electrical machinery and apparatus n.e.c.	2.6	2.0	–0.0	0.7	0.5	0.2
Radio television and communication equipment	2.9	3.1	–0.3	0.1	–0.4	0.5
Medical precision and optical instruments	2.4	1.7	–0.1	0.9	0.3	0.6
Transport equipment	3.2	3.2	–0.3	0.3	–0.3	0.5
Motor vehicles trailers and semi-trailers	3.5	3.2	–0.1	0.4	–0 3	0.6
Other transport equipment	2.6	3.1	–0.6	0.1	–0.1	0.2
Manufacturing n.e.c.; recycling	2.7	1.8	0.1	0.8	0.6	0.2

Source: OECD.

Table A4.4. Labour productivity decompositions Italy, average period: 1987-1992

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	of which	
					Entry	Exit
Total manufacturing	3.9	2.0	0.5	1.4	0.8	0.6
Food products beverages and tobacco	5.1	2.6	0.3	2.3	0.8	1.5
Textiles textile products leather and footwear	3.8	1.7	0.7	1.5	1.3	0.2
Wood and products of wood and cork	4.5	3.4	0.3	0.8	0.6	0.2
Pulp paper paper products printing and publishing	2.7	2.1	0.3	0.3	0.6	–0.3
Chemical rubber plastics and fuel products	4.6	2.2	0.6	1.8	0.8	1.0
Coke refined petroleum products and nuclear fuel	–3.1	–1.7	0.1	–1.5	–1.5	–0.1
Chemicals and chemical products	5.5	2.6	0.7	2.2	1.1	1.1
Chemicals excluding pharmaceuticals	4.8	1.4	0.7	2.6	1.4	1.2
Pharmaceuticals	6.7	4.8	0.6	1.3	0.7	0.7
Rubber and plastics products	4.0	2.1	0.4	1.5	0.5	1.0
Other non-metallic mineral products	4.5	2.8	0.1	1.6	0.4	1.3
Basic metals metal products machinery and equipment	3.5	1.9	0.4	1.3	0.6	0.7
Basic metals and fabricated metal products	4.1	2.2	0.4	1.5	1.0	0.5
Basic metals	4.7	2.0	0.6	2.2	1.1	1.1
Fabricated metal products excl. machinery and equipment	3.9	2.3	0.4	1.2	0.6	0.6
Machinery and equipment	4.1	2.7	0.0	1.5	0.9	0.6
Machinery and equipment n.e.c.	2.9	1.4	0.4	1.0	0.2	0.8
Electrical and optical equipment	5.2	3.7	–0.4	1.9	1.5	0.4
Transport equipment	1.5	–0.3	1.2	0.6	–0.2	0.9
Motor vehicles trailers and semi-trailers	–1.1	–2.2	0.9	0.2	–0.3	0.5
Other transport equipment	5.4	3.3	0.6	1.6	1.0	0.6
Building and repairing of ships and boats	7.8	6.3	0.6	0.9	0.7	0.3
Aircraft and spacecraft	3.0	2.5	–0.2	0.7	0.7	0.0
Manufacturing n.e.c.; recycling	4.7	2.4	0.5	1.7	0.8	0.9

Table A4.4. **Labour productivity decompositions** *(cont.)*
Italy, average period: 1992-1997

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	4.3	2.5	0.5	1.3	0.4	0.9
Food products beverages and tobacco	1.2	1.0	0.5	–0.4	–0.2	–0.1
Textiles textile products leather and footwear	5.2	2.2	0.8	2.2	0.8	1.4
Wood and products of wood and cork	3.8	1.9	0.4	1.6	–0.0	1.6
Pulp paper paper products printing and publishing	4.6	2.5	0.4	1.7	1.1	0.6
Chemical rubber plastics and fuel products	3.1	1.6	0.5	1.0	0.5	0.6
Coke refined petroleum products and nuclear fuel	7.3	2.3	2.7	2.2	–1.6	3.9
Chemicals and chemical products	4.0	1.2	0.8	2.0	0.7	1.3
Chemicals excluding pharmaceuticals	5.5	1.5	1.0	2.9	1.2	1.8
Pharmaceuticals	1.6	0.6	0.5	0.5	–0.1	0.5
Rubber and plastics products	3.5	2.2	0.3	1.1	0.4	0.7
Other non-metallic mineral products	3.7	1.6	0.5	1.6	0.5	1.1
Basic metals metal products machinery and equipment	4.7	3.2	0.3	1.2	0.4	0.8
Basic metals and fabricated metal products	4.6	2.7	0.1	1.7	0.6	1.2
Basic metals	6.4	3.1	0.0	3.3	1.1	2.2
Fabricated metal products excl. machinery and equipment	4.2	2.4	0.1	1.6	0.4	1.2
Machinery and equipment	4.8	3.4	0.4	1.0	0.4	0.6
Machinery and equipment n.e.c.	4.4	2.7	0.2	1.6	0.5	1.0
Electrical and optical equipment	5.3	4.3	0.5	0.5	0.3	0.3
Transport equipment	4.6	2.9	0.1	1.7	0.2	1.5
Motor vehicles trailers and semi-trailers	–1.1	–2.2	0.9	0.2	–0.3	0.5
Other transport equipment	5.4	3.3	0.6	1.6	1.0	0.6
Building and repairing of ships and boats	7.8	6.3	0.6	0.9	0.7	0.3
Aircraft and spacecraft	3.0	2.5	–0.2	0.7	0.7	0.0
Manufacturing n.e.c.; recycling	4.7	2.4	0.5	1.7	0.8	0.9

Source: OECD.

Table A4.5. **Labour productivity decompositions Netherlands, average period: 1987-1992**

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	2.3	1.8	0.1	0.4	0.7	–0.3
Food products beverages and tobacco	1.7	0.9	0.2	0.6	0.1	0.5
Textiles textile products leather and footwear	2.5	1.2	0.7	0.6	0.5	0.1
Wood and products of wood and cork	0.7	0.4	0.1	0.2	0.3	–0.2
Pulp paper paper products printing and publishing	1.8	1.3	0.2	0.4	0.6	–0.2
Chemical and fuel products	2.4	1.5	0.0	0.9	0.8	0.1
Chemical rubber plastics and fuel products	1.9	1.5	0.2	0.3	1.1	–0.8
Chemicals and chemical products	2.6	1.4	0.4	0.9	1.0	–0.1
Chemicals excluding pharmaceuticals	2.6	1.4	0.4	0.9	1.0	–0.1
Rubber and plastics products	1.9	1.2	0.5	0.3	0.4	–0.1
Other non-metallic mineral products	2.4	1.9	–0.1	0.6	0.3	0.3
Basic metals metal products machinery and equipment excl. transport	2.6	2.7	–0.5	0.4	0.1	0.4
Basic metals and fabricated metal products	1.6	0.5	0.2	0.9	0.5	0.4
Basic metals metal products machinery and equipment	3.0	2.4	–0.4	1.0	0.6	0.3
Fabricated metal products excl. machinery and equipment	1.6	0.9	0.2	0.6	0.1	0.5
Machinery and equipment n.e.c.	2.4	1.5	0.2	0.6	0.6	0.1
Machinery and equipment	3.2	3.8	–0.8	0.2	–0.1	0.3
Electrical and optical equipment	4.2	5.0	–0.7	–0.1	–0.4	0.3
Electrical machinery and apparatus n.e.c.	2.6	1.9	0.1	0.6	–0.1	0.7
Radio television and communication equipment	6.0	7.0	–0.3	–0.7	–0.7	0.0
Medical precision and optical instruments	2.9	0.3	0.0	2.5	2.2	0.3
Transport equipment	4.7	0.9	0.1	3.7	3.0	0.7
Motor vehicles trailers and semi-trailers	..	..	..	..	..	..
Other transport equipment	4.7	0.9	0.1	3.7	3.0	0.7
Building and repairing of ships and boats	..	..	..	..	..	..
Manufacturing n.e.c.; recycling	1.4	1.2	0.1	0.1	–1.5	1.7

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Table A4.5. **Labour productivity decompositions** *(cont.)*
Netherlands, average period: 1992-1997

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	4.1	2.8	–0.3	1.5	0.7	0.8
Food products beverages and tobacco	3.1	2.6	–0.4	0.9	0.8	0.1
Textiles textile products leather and footwear	5.7	2.2	0.4	3.1	1.2	1.9
Wood and products of wood and cork	4.6	1.6	0.2	2.8	0.5	2.3
Pulp paper paper products printing and publishing	3.5	2.2	–0.0	1.3	0.6	0.7
Chemical and fuel products	6.0	5.8	–1.6	1.7	0.9	0.9
Chemical rubber plastics and fuel products	5.3	5.0	–1.4	1.8	0.8	1.0
Chemicals and chemical products	6.2	6.1	–1.8	1.9	1.2	0.7
Chemicals excluding pharmaceuticals	6.5	6.0	–1.7	2.2	1.2	1.0
Rubber and plastics products	4.2	2.7	0.1	1.4	1.1	0.3
Other non-metallic mineral products	3.5	2.5	0.3	0.8	0.0	0.8
Basic metals metal products machinery and equipment excl. transport	4.2	3.0	0.1	1.1	–0.0	1.1
Basic metals and fabricated metal products	3.9	3.2	–0.1	0.8	0.1	0.7
Basic metals metal products machinery and equipment	4.0	2.5	0.1	1.3	0.7	0.7
Fabricated metal products excl. machinery and equipment	3.6	2.3	0.0	1.3	0.5	0.8
Machinery and equipment n.e.c.	5.0	3.2	0.5	1.3	0.5	0.8
Machinery and equipment	4.4	2.9	0.3	1.3	–0.1	1.4
Electrical and optical equipment	4.3	2.6	0.2	1.5	–0.3	1.8
Electrical machinery and apparatus n.e.c.	5.8	2.9	0.5	2.4	0.1	2.2
Radio television and communication equipment	2.0	1.0	–0.1	1.0	–0.2	1.2
Medical precision and optical instruments	6.6	5.1	0.6	0.9	0.4	0.6
Transport equipment	3.0	–0.1	–0.3	3.4	3.7	–0.2
Motor vehicles trailers and semi-trailers	6.1	–2.2	2.1	..	6.2	..
Other transport equipment	0.3	1.4	–0.4	–0.7	0.3	–1.0
Building and repairing of ships and boats	3.9	2.4	0.7	..	0.7	..
Manufacturing n.e.c.; recycling	4.2	2.3	0.1	1.9	0.8	1.1

Source: OECD.

Table A4.6. **Labour productivity decompositions Portugal, average period: 1987-1992**

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition			of which	
		Within	Between	Net entry	Entry	Exit
Total manufacturing	5.3	4.0	–0.5	1.8	–0.4	2.2
Food products beverages and tobacco	3.9	2.2	1.2	0.6	–0.5	1.0
Textiles textile products leather and footwear	5.8	4 2	0.1	1.5	–0 6	2.1
Wood and products of wood and cork	5.6	3.2	0.4	2.1	–0.1	2.1
Pulp paper paper products printing and publishing	6.3	4.2	–0.1	2.2	0.1	2.2
Chemical rubber plastics and fuel products	4.6	6 3	–3.3	1.5	0.5	1.1
Chemical and fuel products	5.1	8.1	–3.7	0.6	0.6	0.0
Chemicals and chemical products	5.2	8.2	–3.7	0.6	0.6	0.0
Chemicals excluding pharmaceuticals	5.1	9.9	–4.3	–0.5	–0.5	–0.0
Pharmaceuticals	6.4	5.8	–0.4	1.0	0.7	0.4
Rubber and plastics products	5.5	1.4	1.1	3.0	0.0	3.0
Other non-metallic mineral products	7.9	4.7	0.5	2.7	1.2	1.6
Basic metals metal products machinery and equipment	4.8	2 9	–0.1	2.1	0.2	1.9
Basic metals metal products machinery and equipment excl. transport	4.0	3.0	–0.3	1.4	0.2	1.1
Basic metals and fabricated metal products	3.5	2 8	–0.1	0.9	–0 1	1.0
Basic metals	3.5	3.9	–1.0	0.5	–0.4	1.0
Fabricated metal products excl. machinery and equipment	4.0	2.4	0.6	1.1	0.2	0.9
Machinery and equipment	4.0	3.3	–0.7	1.4	0.3	1.2
Machinery and equipment n.e.c.	7.0	3.3	1.2	2.5	0.7	1.8
Electrical and optical equipment	1.0	3.7	–2.6	–0.1	–0.4	0.3
Office accounting and computing machinery	7.9	4 7	0.2	3.0	0.4	2.6
Electrical machinery and apparatus n.e.c.	–3.8	3.4	–4.3	–2.9	–3.6	0.7
Radio television and communication equipment	5.6	4.4	–0.9	2.1	1.8	0.3
Medical precision and optical instruments	–2.3	–0.6	–0.3	–1.3	–1.5	0.2
Transport equipment	7.4	2.2	1.0	4.3	0.2	4.0
Motor vehicles trailers and semi-trailers	3.9	3.1	1.0	–0.2	–1.7	1.5
Other transport equipment	8.8	1.6	0.5	6.7	2.4	4.3
Building and repairing of ships and boats	9.7	–2.0	0.4	11.3	3.9	7.4
Railroad equipment and transport equipment n.e.c.	7.8	6 4	0.7	0.8	1.4	–0.6
Manufacturing n.e.c.; recycling	6.1	4.4	0.3	1.4	–0 2	1.5

Table A4.6. Labour productivity decompositions *(cont.)*
Portugal, average period: 1992-1997

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	4.7	3.1	–0.3	1.9	0.0	1.9
Food products beverages and tobacco	–2.4	1.3	–1.9	. .	–1.8	. .
Textiles textile products leather and footwear	4.7	3 0	0.2	1.5	–0 5	2.0
Wood and products of wood and cork	–0.4	–3.3	0.6	2.4	–0.5	2.8
Pulp paper paper products printing and publishing	0.8	0.4	0.1	0.3	1.4	–1.1
Chemical rubber plastics and fuel products	2.9	2 9	–0.4	0.4	–1 0	1.3
Chemical and fuel products	2.7	2.7	–0.7	0.7	–1.3	2.1
Chemicals and chemical products	3.4	3.4	–0.8	0.7	–1.3	2.0
Chemicals excluding pharmaceuticals	0.6	2 9	–0.9	–1.4	–2.0	0.6
Pharmaceuticals	5.8	2.8	0.5	2.5	–0.7	3.2
Rubber and plastics products	4.3	3.1	1.0	0.3	–0.1	0.4
Other non-metallic mineral products	6.0	3.3	0.0	2.6	0.4	2.2
Basic metals metal products machinery and equipment	8.7	6 2	–0.7	3.2	1.8	1.4
Basic metals metal products machinery and equipment excl. transport	7.9	5.9	–0.2	2.1	1.0	1.1
Basic metals and fabricated metal products	7.1	4 2	0.2	2.7	1.6	1.1
Basic metals	4.2	0.2	–0.4	4 4	3.8	0.8
Fabricated metal products excl. machinery and equipment	8.8	5 7	0.3	2.8	1.3	1.5
Machinery and equipment	8.1	7.2	–0.7	1.6	0.7	0.9
Machinery and equipment n.e.c.	6.6	5.3	0.1	1.2	0.2	1.0
Electrical and optical equipment	8.6	8 5	–1.5	1.7	1.0	0.7
Electrical machinery and apparatus n.e.c.	10.1	9 3	–2.0	2.8	0.5	2.2
Radio television and communication equipment	8.8	7.2	–0.8	2.4	1.5	0.8
Medical precision and optical instruments	9.7	7.6	–0.3	2.4	0.5	1.8
Transport equipment	12.8	7.6	–1.7	6.9	4.3	2.6
Motor vehicles trailers and semi-trailers	13.6	7.5	–3.2	9.2	6.0	3.2
Other transport equipment	7.4	8.9	–0.3	–1.2	–0.3	–0.9
Building and repairing of ships and boats	8.4	21.1	–8.9	–3.8	–0.4	–3.5
Railroad equipment and transport equipment n.e.c.	1.4	3.8	–0.3	–2.1	–0.5	–1.6
Manufacturing n.e.c.; recycling	–9.7	–7 4	–0.1	–2.2	–2.2	–0.0

Source: OECD.

Table A4.7. **Labour productivity decompositions United Kingdom, average period: 1987-1992**

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	2.5	1.5	0.3	0.8	0.0	0.7
Food products beverages and tobacco	1.2	1.5	–0.1	–0.3	–0.6	0.3
Textiles textile products leather and footwear	2.8	1.6	0.1	1.1	–0.1	1.1
Wood and products of wood and cork	–0.9	–0.4	–0.7	0.2	0.1	0.1
Pulp paper paper products printing and publishing	3.1	1.7	0.2	1.2	0.1	1.1
Chemical rubber plastics and fuel products	1.2	1.4	–0.3	0.1	–0.0	0.1
Chemical and fuel products	2.3	1.8	–0.6	1.1	0.9	0.2
Chemicals and chemical products	2.5	1.8	–0.6	1.3	0.9	0.3
Chemicals excluding pharmaceuticals	2.0	1.5	–0.7	1.2	0.8	0.4
Pharmaceuticals	4.0	2.6	0.1	1.3	1.1	0.2
Rubber and plastics products	0.5	0.7	0.2	–0.4	–0.7	0.3
Other non-metallic mineral products	0.2	–0.4	0.3	0.3	0.8	–0.5
Basic metals metal products machinery and equipment	2.8	1.7	0.5	0.6	0.0	0.6
Basic metals metal products machinery and equipment excl. transport	2.9	1.7	0.4	0.8	0.2	0.7
Basic metals and fabricated metal products	1.2	1.1	–0.2	0.4	–0.5	0.8
Basic metals	2.8	2.2	–0.4	1.0	0.1	0.9
Fabricated metal products excl. machinery and equipment	1.1	0.4	0.1	0.6	–0.4	1.0
Machinery and equipment	3.7	2.0	0.7	1.1	0.5	0.6
Machinery and equipment n.e.c.	2.0	1.5	–0.1	0.6	0.0	0.6
Electrical and optical equipment	4.8	2.3	1.2	1.4	0.8	0.5
Office accounting and computing machinery	7.8	0.9	3.2	3.7	2.7	1.0
Electrical machinery and apparatus n.e.c.	3.4	2.6	0.3	0.5	0.3	0.2
Radio television and communication equipment	4.1	2.7	0.9	0.5	–0.1	0.7
Medical precision and optical instruments	3.4	2.4	0.2	0.8	–0.0	0.8
Transport equipment	2.8	1.7	0.8	0.3	–0.4	0.7
Motor vehicles trailers and semi-trailers	1.4	0.6	0.5	0.2	–0.6	0.8
Other transport equipment	3.3	3.0	0.5	–0.2	0.2	–0.4
Building and repairing of ships and boats	6.3	4.5	0.7	1.2	0.6	0.7
Aircraft and spacecraft	2.6	2.6	0.0	0.1	0.2	–0.1
Railroad equipment and transport equipment n.e.c.	3.9	3.3	0.4	0.1	0.2	–0.0
Manufacturing n.e.c.; recycling	0.7	0.4	0.3	–0.0	–0.5	0.5

Table A4.7. Labour productivity decompositions *(cont.)*
United Kingdom, average period: 1992-1997

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	3.1	2.4	–0.2	0.9	–0.1	1.1
Food products beverages and tobacco	–1.0	0.4	–0.8	–0.6	–0.2	–0.4
Textiles textile products leather and footwear	2.8	2.2	–0.5	1.1	0.2	1.0
Wood and products of wood and cork	2.2	1.5	0.9	–0.2	–1.2	1.0
Pulp paper paper products printing and publishing	0.5	1.3	–0.2	–0.7	–1.6	0.9
Chemical rubber plastics and fuel products	1.3	2.5	–0.6	–0.6	–0.9	0.3
Chemical and fuel products	1.6	3.0	–0.4	–1.0	–1.1	0.2
Chemicals and chemical products	2.1	3.0	–0.4	–0.5	–1.0	0.5
Chemicals excluding pharmaceuticals	1.5	3.1	–0.8	–0.7	–1.3	0.6
Pharmaceuticals	3.4	2.9	0.7	–0.1	–0.3	0.2
Rubber and plastics products	1.2	1.8	–0.2	–0.4	–0.7	0.2
Other non-metallic mineral products	2.4	1.8	–0.3	0.9	0.7	0.2
Basic metals metal products machinery and equipment	5.4	3.5	0.1	1.8	0.2	1.6
Basic metals metal products machinery and equipment excl. transport	5.2	3.0	0.3	1.8	0.7	1.1
Basic metals and fabricated metal products	3.1	2.4	0.2	0.6	–0.9	1.5
Basic metals	4.4	3.0	–0.1	1.5	–0.2	1.7
Fabricated metal products excl. machinery and equipment	1.8	1.9	–0.0	–0.1	–0.7	0.5
Machinery and equipment	6.0	3.3	0.4	2.3	1.3	1.0
Machinery and equipment n.e.c.	3.8	2.8	0.1	0.9	0.0	0.9
Electrical and optical equipment	7.4	3.7	0.6	3.2	2.1	1.1
Office accounting and computing machinery	14.9	4.6	–0.1	10.4	5.6	4.8
Electrical machinery and apparatus n.e.c.	6.0	3.8	–0.1	2.4	0.7	1.7
Radio television and communication equipment	8.6	4.0	1.0	3.7	1.7	2.0
Medical precision and optical instruments	2.8	2.7	–0.1	0.1	0.2	–0.1
Transport equipment	6.3	4.5	–0.2	1.9	–0.5	2.4
Motor vehicles trailers and semi-trailers	4.9	4.8	–0.6	0.7	–1.0	1.7
Other transport equipment	7.6	4.2	–0.0	3.4	0.8	2.6
Building and repairing of ships and boats	4.1	3.8	0.1	0.2	–1.0	1.2
Aircraft and spacecraft	9.2	4.9	–0.1	4.5	1.8	2.7
Railroad equipment and transport equipment n.e.c.	2.0	0.6	0.6	0.9	–1.1	2.0
Manufacturing n.e.c.; recycling	2.0	0.8	0.3	0.9	–0.4	1.3

Source: OECD.

Table A4.8. **Labour productivity decompositions United States, average period: 1987-1992**

Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	*of which*	
					Entry	Exit
Total manufacturing	1.6	1.4	–0.1	0.3	–0.9	1.2
Food products beverages and tobacco	0.6	0.7	–0.4	0.3	–0 4	0.7
Textiles textile products leather and footwear	1.4	0 7	0.7	–0.0	–1 4	1.4
Wood and products of wood and cork	–1.2	–0.8	0.3	–0.6	–0.7	0.1
Pulp paper paper products printing and publishing	0.2	0.3	0.1	–0.2	–0.8	0.6
Coke refined petroleum products and nuclear fuel	2.1	1.2	0.8	0.2	0.1	0.0
Chemicals and chemical products	0.6	1.1	–0.4	–0.2	–0.7	0.6
Rubber and plastics products	1.6	1.4	–0.0	0.3	–0.4	0.6
Other non-metallic mineral products	0.5	0.6	–0.3	0.2	–0.6	0.8
Basic metals	1.2	0.8	–0.2	0.5	–0.2	0.7
Fabricated metal products excl. machinery and equipment	0.7	0.3	0.3	0.1	–0.3	0.4
Machinery and equipment n.e.c.	1.2	1.1	–0.1	0.3	–0 3	0.6
Office accounting and computing machinery	11.2	9.0	–0.7	2.9	0.7	2.2
Electrical machinery and apparatus n.e.c.	4.2	3.4	0.0	0.8	–0.3	1.1
Radio television and communication equipment	6.8	4 6	0.4	1.7	0.1	1.7
Medical precision and optical instruments	3.0	2.7	–0.1	0.3	–0.4	0.8
Motor vehicles trailers and semi-trailers	1.7	2.2	–0.9	0.4	–0.8	1.2
Building and repairing of ships and boats	–0.2	–0.6	0.3	0.1	–1.0	1.0
Aircraft and spacecraft	3.0	3.0	0.2	–0.2	–0.3	0.2
Railroad equipment and transport equipment n.e.c.	3.2	2.5	–0.2	1.0	–0.2	1.1
Manufacturing n.e.c.; recycling	1.3	0.4	0.3	0.6	–0.3	0.9

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Table A4.8. Labour productivity decompositions *(cont.)*
United States, average period: 1992-1997

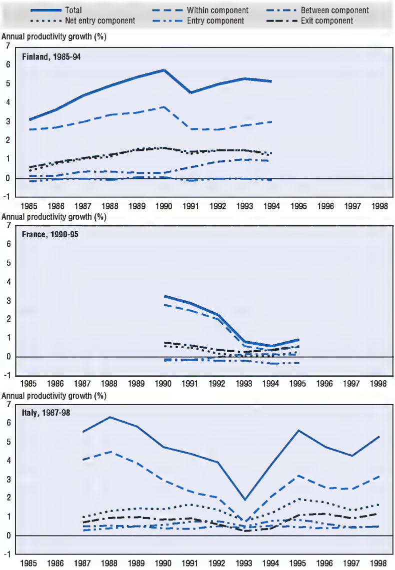
Decomposition based on the Griliches and Regev (1995) approach

Industries	Productivity growth (annual % change)	Decomposition				
		Within	Between	Net entry	of which	
					Entry	Exit
Total manufacturing	3.0	3.0	–0.6	0.6	–0.8	1.4
Food products beverages and tobacco	0.8	2.1	–1.3	–0.1	–1.1	1.0
Textiles textile products leather and footwear	4.2	2.4	0.6	1.2	–1.2	2.5
Wood and products of wood and cork	–0.3	–0.4	0.4	–0.3	–0.8	0.5
Pulp paper paper products printing and publishing	0.9	1.0	–0.3	0.2	–0.6	0.7
Coke refined petroleum products and nuclear fuel	6.7	6.2	0.3	0.3	–0.2	0.4
Chemicals and chemical products	2.9	3.3	–0.7	0.2	–0.2	0.4
Rubber and plastics products	2.3	2.1	–0.1	0.4	–0.4	0.8
Other non-metallic mineral products	2.3	1.8	–0.1	0.6	–0.4	1.0
Basic metals	2.4	3.1	–1.0	0.4	–0.2	0.6
Fabricated metal products excl. machinery and equipment	2.1	2.0	–0.2	0.3	–0.2	0.5
Machinery and equipment n.e.c.	3.0	2.7	–0.1	0.3	–0.4	0.7
Office accounting and computing machinery	18.7	16.3	0.0	2.4	0.5	1.9
Electrical machinery and apparatus n.e.c.	4.5	3.0	–0.3	1.8	1.0	0.8
Radio television and communication equipment	13.0	11.7	–0.5	1.7	0.0	1.7
Medical precision and optical instruments	3.7	3.3	–0.5	0.9	–0.0	0.9
Motor vehicles trailers and semi-trailers	2.9	4.3	–1.6	0.2	–0.8	1.1
Building and repairing of ships and boats	–0.6	0.2	–1.0	0.2	–0.9	1.1
Aircraft and spacecraft	2.9	2.2	0.0	0.6	–0.3	0.9
Railroad equipment and transport equipment n.e.c.	2.5	2.3	0.0	0.3	–0.5	0.8
Manufacturing n.e.c.; recycling	0.1	0.6	–0.8	0.3	–0.7	1.0

Source: OECD.

Figure A4.1. **The evolution of labour productivity and its components, total manufacturing**

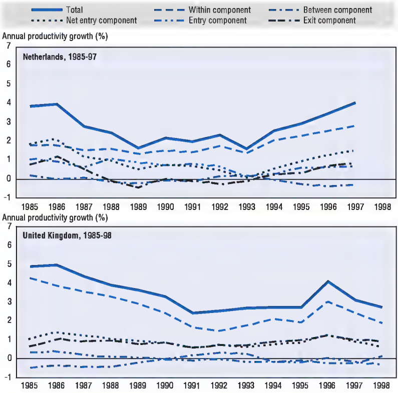
Decomposition based on Griliches and Regev (1995) approach



Source: OECD.

Figure A4.1. **The evolution of labour productivity and its components, total manufacturing** *(cont.)*

Decomposition based on Griliches and Regev (1995) approach



Source: OECD.

Figure A4.2. **Decomposition of multi-factor productivity growth, total manufacturing**

Decomposition based on Griliches and Regev (1995) approach

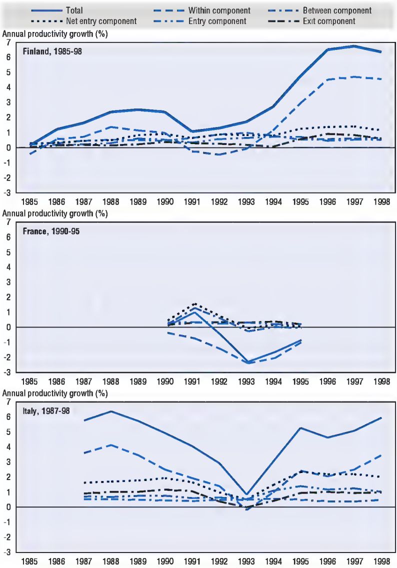
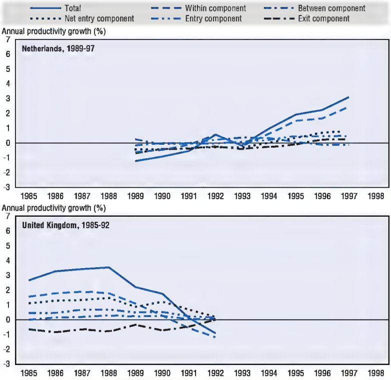


Figure A4.2. **Decomposition of multi-factor productivity growth, total manufacturing** *(cont.)*

Decomposition based on Griliches and Regev (1995) approach



Source: OECD.

Annex 5

Basic data and sources

A5.1. Chapter 1

Data sources and links with national sources

The main source of data used in Chapter 1 is the OECD *Economic Outlook* (EO) Database. Several specific adjustments were made to data on hours worked, which are discussed below. Refined estimates of MFP growth also required information drawn from additional sources. For example, data on compositional changes of the capital stock and on the flow of capital services in nine countries were obtained from a recent OECD work (Colecchia and Schreyer, 2002). Similarly, the data needed to differentiate labour input by type of worker were from OECD *Education at a Glance*, OECD Database (several issues). Basic data for international comparison of income and productivity levels are presented in Table A5.1.

In individual cases, a decision was taken to use alternative sources or to construct specific estimates in order to enhance time-series and cross-country comparability in the derived growth rates. Specific adjustments were made for three countries: United Kingdom, Canada and United States. In a specific subsection for each country, these adjustments are discussed and compared with national sources. Among the most important adjustments are those concerning capital stock series for the United States and Canada. These adjustments reflect efforts to use a gross capital stock measure for productivity calculations, so as to be in line with the majority of data available for other countries.

Hours worked

Estimates of hours worked come mainly from national or EU sources:

- For Austria, Belgium, Denmark, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and the United Kingdom, a country-specific adjustment has been applied to data from the European Labour Force Survey (EULFS). This adjustment factor varies by year and is obtained as the ratio of adjusted *versus* non-adjusted estimates of hours worked based on the EULFS under the assumption that there is a 50 per cent underestimation

Table A5.1. Basic data for international comparaison of income and productivity, 2000

	GDP at 1996 prices (billion NC)	Trend GDP at 1996 prices (billion NC)	1996 PPPs	GDP at 1996 prices (million US$)	Trend GDP at 1996 prices (million US$)	Population (1 000s)	Working-age population (15-64 years) (1 000s)	Employment[1] (1 000s)	Trend employment[1] (1 000s)	Annual hours worked per person employed[2]	Trend annual hours worked per person employed[2]	GDP at 1996 prices per capita (US$)	Trend GDP at 1996 prices per capita (US$)	GDP at 1996 prices per person employed (US$)	Trend GDP at 1996 prices per person employed (US$)
United States	9 223.8	9 120.2	1.0	9 223 842	9 120 189	275 372	181 954	135 215	134 835	1 867	1 867	33 496	33 120	68 216	67 450
Japan	526 119.5	529 202.2	165.6	3 176 760	3 195 374	126 886	86 220	64 461	65 043	1 842	1 820	25 036	25 183	49 282	49 571
Germany	3 889.6	3 858.1	2.0	1 918 522	1 902 944	82 143	55 463	38 706	38 243	1 556	1 541	23 356	23 166	49 567	49 164
France	8 932.7	8 835.4	6.6	1 359 254	1 344 456	58 892	38 338	23 831	23 576	1 600	1 594	23 080	22 829	57 038	56 417
Italy	2 066 343.2	2 054 733.0	1 583.0	1 305 340	1 298 006	57 762	38 787	20 874	20 655	1 634	1 631	22 599	22 472	62 534	62 182
United Kingdom	853.2	848.9	0.6	1 324 790	1 318 187	59 766	39 079	27 938	27 711	1 561	1 568	22 166	22 056	47 419	47 183
Canada	997.8	979.6	1.2	841 803	826 497	30 750	21 040	14 911	14 710	1 785	1 783	27 376	26 878	56 455	55 428
Australia	610.3	604.3	1.3	469 673	465 070	19 157	12 876	9 097	9 029	1 801	1 802	24 517	24 277	51 632	51 126
Austria	2 727.3	2 718.2	13.6	200 854	200 184	8 106	5 495	4 046	4 027	1 576	1 572	24 778	24 696	49 649	49 483
Belgium	9 484.0	9 379.6	36.8	257 554	254 718	10 251	6 719	3 970	3 937	1 554	1 570	25 125	24 848	64 875	64 161
Czech Republic	1 575.4	1 584.6	11.7	134 766	135 555	10 273	7 165	4 676	4 713	2 017	2 017	13 118	13 195	28 823	28 992
Denmark	1 183.1	1 175.7	8.3	142 068	141 175	5 337	3 561	2 727	2 710	1 541	1 531	26 619	26 452	52 090	51 762
Finland	721.2	700.7	5.9	122 534	119 044	5 181	3 467	2 326	2 258	1 680	1 680	23 651	22 977	52 676	51 175
Greece	34 590.7	34 018.3	213.9	161 713	159 037	10 543	7 053	3 898	3 908	1 945	1 942	15 338	15 085	41 491	40 804
Hungary	8 281.7	7 951.8	72.6	114 150	109 602	10 024	6 852	3 784	3 659	1 795	1 799	11 388	10 934	30 163	28 961
Iceland	578.7	566.7	76.8	7 540	7 383	281	183	139	137	1 804	1 789	26 814	26 257	54 278	53 151
Ireland	68.0	65.9	0.7	101 098	97 976	3 787	2 539	1 616	1 564	1 700	1 707	26 697	25 872	62 573	60 641
Korea	494 748.1	493 777.8	629.2	786 260	784 718	47 275	33 671	21 061	21 138	2 497	2 444	16 632	16 599	37 333	37 260
Luxembourg	739.6	730.6	39.7	18 625	18 399	439	293	183	182	1 643	1 638	42 474	41 958	101 641	100 405
Mexico	3 144.0	3 082.8	3.8	829 696	813 542	97 379	59 367	40 866	40 766	1 921	1 931	8 520	8 354	20 303	19 907
Netherlands	807.3	800.9	2.0	394 809	391 718	15 926	10 801	6 959	6 912	1 347	1 339	24 790	24 596	56 734	56 289
New Zealand	105.4	104.8	1.5	71 287	70 928	3 831	2 503	1 779	1 792	1 825	1 829	18 609	18 515	40 072	39 870
Norway	1 126.6	1 135.3	9.1	123 614	124 569	4 491	2 911	2 269	2 261	1 395	1 391	27 525	27 738	54 480	54 901
Poland	470.0	465.3	1.4	344 432	340 938	38 646	26 527	14 526	14 682	..	..	8 912	8 822	23 711	23 471
Portugal	19 932.4	19 792.0	122.4	162 862	161 715	10 008	6 798	4 877	4 843	1 757	1 746	16 273	16 158	33 396	33 161
Slovak Republic	697.9	..	12.2	57 224	..	5 401	3 730	2 102	..	..	..	10 596	..	#N/A	..
Spain	90 874.8	89 690.7	123.7	734 757	725 183	39 466	26 892	14 473	14 082	1 827	1 823	18 617	18 375	50 768	50 107
Sweden	2 002.3	1 965.8	9.7	206 888	203 123	8 872	5 705	4 156	4 069	1 634	1 645	23 319	22 895	49 774	48 869

Table A5.1. **Basic data for international comparaison of income and productivity, 2000** *(cont.)*

	GDP at 1996 prices (billion NC)	Trend GDP at 1996 prices (billion NC)	1996 PPPs	GDP at 1996 prices (million US$)	Trend GDP at 1996 prices (million US$)	Population (1 000s)	Working-age population (15-64 years) (1 000s)	Employment[1] (1 000s)	Trend employment[1] (1 000s)	Annual hours worked per person employed[2]	Trend annual hours worked per person employed[2]	GDP at 1996 prices per capita (US$)	Trend GDP at 1996 prices per capita (US$)	GDP at 1996 prices per person employed (US$)	Trend GDP at 1996 prices per person employed (US$)
Switzerland	398.6	394.4	2.1	194 219	192 189	7 185	4 843	3 910	3 902	1 589	1 587	27 031	26 749	49 672	49 153
Turkey	16 720 410.1	16 872 105.9	39 274.6	425 730	429 593	66 835	43 587	21 078	21 325	..	..	6 370	6 428	20 198	20 381
North America				10 895 342	10 760 227	403 501	262 361	190 992	190 311	1 872	1 874	27 002	26 667	57 046	56 339
European Union				8 411 669	8 335 865	376 479	250 989	160 579	158 677	1 610	1 605	22 343	22 142	52 383	51 911
G7				19 150 312	19 005 653	691 571	460 881	325 936	324 772	1 761	1 755	27 691	27 482	58 755	58 311
Euro area				6 737 923	6 673 381	302 503	202 645	125 757	124 187	1 622	1 614	22 274	22 061	53 579	53 066

1. 1999 for Ireland.
2. 1998 for Austria and New Zealand, 1999 for Switzerland.

Source: OECD.

of time lost due to illness and maternity. The average adjustment factor for the countries reported above is 0.97.

- For Finland and Iceland, an average adjustment factor derived from the EULFS has been applied to national Labour Force Survey (LFS) estimates due to the limited length of EULFS series.
- For Australia, Czech Republic, Korea, and New Zealand, data come from national LFS, adjusted with the average adjustment factor of 0.97.
- For Canada, France, Germany, Hungary, Japan, Norway, Spain, Sweden, and Switzerland, data are national estimates (either from LFS, or from national accounts/enterprise surveys). For the United States data are the BLS estimate of total hours worked on the basis of the Current Population Survey, the Current Employment Statistics, and the Hours at Work Survey, divided by the average number of employed persons.
- For Mexico hours worked are based on a level estimate from Maddison (1995) for 1992 and a time series from the National Survey of Employment (see OECD, 1999c, for more detailed information on national sources).

Where possible, estimates have also been extended backwards through splicing with the estimates from Maddison (1995). See Scarpetta *et al.* (2000) for more details.

United States

Output

Small differences occur, because the OECD Economic Outlook (EO) business sector data is based on national income and product accounts data. Also, the BLS business sector output measures exclude government enterprises to be fully consistent with its capital input series. The OECD series does not make this adjustment and therefore includes government enterprises. Also, the adjustment in the EO database to move from an aggregate for the total economy to the value-added of the business sector is not identical to national procedures.

Labour

The number of persons in the OECD series is taken from employment data as published in the United States' National Income and Product Accounts. It reflects persons employed in production, *i.e.* the number of employees plus self-employed. Hours worked per person were derived separately, as discussed above. BLS, in its multi-factor productivity series, uses an index of labour input. Conceptually, the measure of labour input is similar to the OECD's labour input measure as described in Annex 1: it reflects total hours worked, adjusted for changes in the composition of the quality of

Table A5.2. **Average hours worked annually, 1980-2000**

Total economy	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	1 822	1 812	1 806	1 824	1 840	1 835	1 827	1 833	1 837	1 848	1 838	1 826	1 828	1 837	1 839	1 848	1 837	1 849	1 850	1 846	1 835
Japan	2 121	2 106	2 104	2095	2 108	2093	2097	2096	2092	2070	2031	1998	1965	1905	1 898	1 884	1 892	1 864	1 842	1 810	1 821
Germany[1]	1 720	1 703	1 703	1 697	1 690	1 666	1 659	1 647	1 646	1 620	1 583	1 560	1 576	1 556	1 555	1 535	1 519	1 513	1 507	1 496	1 482
France	1 795	1 760	1 718	1 712	1 700	1 685	1 676	1 671	1 673	1 655	1 657	1 645	1 646	1 642	1 639	1 614	1 608	1 605	1 603	1 596	1 590
Italy	1 717	1 710	1 703	1 692	1 677	1 665	1 663	1 658	1 675	1 672	1 674	1 668	1 636	1 637	1 634	1 635	1 636	1 640	1 629	1 625	1 622
United Kingdom	1 769	1 712	1 727	1 713	1 729	1 762	1 765	1 754	1 794	1 782	1 767	1 768	1 729	1 723	1 737	1 739	1 738	1 737	1 731	1 719	1 708
Canada	1 802	1 801	1 784	1 780	1 782	1 790	1 789	1 797	1 807	1 801	1 788	1 767	1 759	1 763	1 780	1 775	1 784	1 790	1 787	1 791	1 795
Australia	1 878	1 878	1 867	1 853	1 869	1 866	1 848	1 860	1 881	1 870	1 866	1 853	1 845	1 870	1 875	1 872	1 862	1 861	1 856	1 860	1 855
Austria	..	..	..	..	..	1 595	1 595	1 595	1 607	1 591	1 586	1 581	1 576	1 576	1 576	1 576	1 576	1 576	1 576	..	..
Belgium	..	..	..	1 684	1 704	1 711	1 697	1 686	1 680	1 668	1 679	1 646	1 629	1 590	1 592	1 622	1 594	1 607	1 611	1 553	1 530
Czech Republic	..	..	..	..	..	..	..	..	..	..	..	..	..	2064	2043	2064	2066	2067	2075	2088	2092
Denmark	..	..	..	..	1 536	1 553	1 534	1 514	1 531	1 508	1 492	1 484	1 503	1 469	1 539	1 501	1 509	1 520	1 519	1 544	1 504
Finland	1 846	1 831	1 810	1 809	1 810	1 804	1 777	1 802	1 824	1 802	1 763	1 741	1 762	1 739	1 777	1 772	1 789	1 780	1 761	1 765	1 721
Greece	..	..	..	1983	1917	1945	1929	1 889	1 882	1913	1912	1916	1944	1964	1932	1922	1939	1924	1921	1940	1921
Hungary[2]	1930	1928	1 847	1 829	1 765	1 742	1 734	1 772	1 768	1 746	1 710	1 682	1 644	1 644	1 759	1 765	1 777	1 786	1 788	1 795	1 795
Iceland	..	..	..	..	..	..	..	..	..	..	..	1 843	1 859	1 828	1 813	1 832	1 860	1 839	1 817	1 873	1 885
Ireland	..	..	..	1909	1901	1905	1936	1924	1921	1929	1922	1 892	1 844	1 832	1 835	1 835	1 836	1 797	1 722	1 693	1 690
Korea	2 689	2 705	2 717	2 734	2 730	2 706	2 734	2 705	2 662	2 564	2 514	2 498	2 478	2 477	2 471	2 484	2 467	2 436	2 390	2 497	2 474
Mexico	..	..	..	..	..	..	..	..	..	..	..	1 822	..	1 821	..	1 857	1901	1927	1 878	1921	1 888
Netherlands	..	..	..	..	..	1 437	..	1 514	1 480	1 469	1 454	1 427	1 393	1 364	1 391	1 365	1 387	1 380	1 364	1 345	1 381
New Zealand	..	..	..	..	..	..	..	1 851	1 845	1 832	1 820	1 802	1 812	1 844	1 851	1 843	1 838	1 823	1 825	1 842	1 817
Norway	1 512	1 502	1 490	1 485	1 479	1 473	1 469	1 443	1 444	1 440	1 432	1 427	1 437	1 434	1 431	1 414	1 407	1 401	1 400	1 395	1 376
Portugal	..	..	..	..	..	..	1 842	1 861	1 859	1 889	1 882	1 808	1 797	1 788	1 784	1 822	1 799	1 760	1 746	1 761	1 719
Slovak Republic	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1975	1993	2023	2055	2034	2022	2023
Spain	..	..	..	..	..	..	..	..	..	..	..	1 833	1 825	1 816	1 816	1 815	1 810	1 813	1 834	1 816	1 814
Sweden	1 505	1 497	1 511	1 520	1 522	1 526	1 524	1 534	1 553	1 552	1 549	1 536	1 553	1 570	1 602	1 614	1 623	1 628	1 629	1 636	1 625
Switzerland	..	..	..	..	..	..	..	..	..	..	..	1 606	1 605	1 607	1 623	1 599	1 595	1 589	1 589	1 597	1 568

1. Western Germany before 1991.
2. Dependent employment.

Source: *OECD Employment Outlook*, 2002.

labour. Although BLS is able to use a much finer level of differentiation between types of labour, the two labour input measures differ only slightly over the period under consideration. While this difference would appear small, it may be the result of compensating differences or simply due to the specific period chosen for comparison.

Capital

As pointed out earlier, for its basic MFP series, OECD uses an estimated measure of the gross capital stock,[1] while available data in the EO database refer to a concept of net capital stock as published by BEA. BLS, akin to its labour input measure, uses a measure of capital services that reflects both the quantity and the changing composition of capital input. The underlying concept is briefly described in Annex 1 as well as in Chapter 1. As expected, the gross capital stock measure grows by much less than BLS' capital service measure. However, there is significant similarity between OECD's capital service series and that of BLS. The construction of the OECD capital service data is described above.

Canada

Output

There are only minor differences between OECD business sector series and the ones published by Statistics Canada, due to differences in the definition of the business sector.

Labour

The number of persons in the OECD series is taken from employment data as published by Statistics Canada's Input-Output Division. Series on both the number of persons and on total hours are available. Statistics Canada, in its multi-factor productivity series, uses an index of labour input. Conceptually, this labour input measure is not as elaborate as the one used by BLS but is more developed than a simple sum of all hours worked. Differentiation takes place by industry, because each industry's contribution to the economy's labour input is weighted by the share that a given industry occupies in the economy's total labour compensation. If average wages in an industry exceed those of other sectors, an implicit weighting of hours by industry takes place. However, there is no explicit differentiation by educational attainment or the skills of workers.

Capital

As pointed out earlier, for its basic MFP series, OECD uses an estimated measure of the gross capital stock. For Canada, gross capital stock is the

Statistics Canada capital stock series that is constructed on a one-hoss shay age-efficiency pattern. Statistics Canada's own MFP calculations use as input another of their capital stock series, one based on a geometric age-efficiency pattern. A second difference lies in the aggregation procedure: Statistics Canada uses a Fisher index number formula to aggregate capital input across industries. The gross capital stock measure used by OECD is based on a Laspeyres-type aggregation formula. Again, the final outcome does not differ by much, although this reflects the combined, and partly offsetting, effects of a different age-efficiency pattern and a different index number formula.

United Kingdom

In the United Kingdom, time series for business sector GDP and employment have been corrected to take into account the fact that the National Health Service (NHS) Trust, created in 1991, is not accounted for in the government sector. Conversely all public health services were accounted for in the government sector before 1991. For comparability reasons both employment and GDP of NHS Trust have been subtracted from business sector series. The method of calculation of GDP of NHS Trust is as follows: first on the basis of United Kingdom *Abstract of Statistics, 1998*, a productivity level at current prices of NHS Staff was computed on the basis of Total Current Expenditure on the NHS (item KJQJ) and Total Employment of NHS (items KDBC+KDBO+KWUH). Then a real (at 1995 prices) productivity was computed through the implicit deflator of Health and Social Work sector (Sector N in the National Accounts – *National Accounts, 1998* – Blue Book). Then this productivity was applied to data on NHS Trust staff.

A5.2. Chapter 2

The data used in Chapter 2 are from the following sources:

- Data on GDP, working age population, gross fixed capital formation, general government current nominal tax and non-tax receipts, direct and indirect taxes, government nominal final consumption and imports and exports are from the OECD *Economic Outlook (EO)* Data Base. Purchasing Power Parity benchmarks for 1993 are from the OECD Statistics Directorate. In the case of Norway, data refer to the mainland economy. In the case of Greece and Portugal the ratio between total gross fixed capital formation and total real GDP was used as a proxy for the investment rate (*i.e.* the ratio of private non-residential fixed capital formation to business sector real GDP), due to data availability.
- Data on Research and Development (R&D) are from the OECD Main Science and Technology Indicators (MSTI) database. A few missing observations were obtained by interpolation.

- Data on human capital are calculated on the basis of raw data on educational attainment from De la Fuente and Doménech (2000)[2] and from the OECD *Education at a Glance* (various issues). In particular: three educational groups were considered: below upper secondary education (ISCED 0 to ISCED 2); upper secondary education (ISCED 3); and tertiary education (ISCED 5 to ISCED 7). For the 1990s, the level of educational attainment for male and female workers is available from matched OECD sources for the following countries: Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, New Zealand, Norway, Portugal, Sweden, United Kingdom, United States. For Austria, Belgium, Czech Republic, Greece, Hungary, Korea, Mexico, Poland, Spain, Switzerland and Turkey the calculation of labour input was not possible due to the unavailability of either the educational composition of employment or relative wages by education level. Until the early 1980s, data on educational attainment are interpolated from five-year observations from De la Fuente and Doménech (2000). The cumulative years of schooling by educational level – required to estimate the average number of years of total schooling used in the empirical analysis – are from the OECD *Education at a Glance* 1997 (OECD, 1998c).

The indicators measuring financial market developments are discussed in Leahy *et al.* (2001).

The definition of each variable is provided in Box 2.3 of Chapter 2. The exact country coverage of the variables, as well as basic statistics, can be found in Annex 1 of Bassanini *et al.* (2001).

A5.3. Chapter 3

Industry-level data

Productivity data

The industry-level data used in section 3.1 of Chapter 3 comes from different versions of the structural analysis (STAN) database. The industries considered in the productivity analysis of Chapters 3 and 4 – and, for manufacturing, their classification according to the market structure typologies discussed in Box 3.4 of Chapter 3 – are presented in Table A5.4, while Table A5.5 presents the coverage of the available data. Three main data-sets have been used to construct the value-added, capital stock, employment and labour compensation series necessary to compute multifactor productivity series at the firm-level. The main data-set is the OECD STAN-2000 database. It was updated for missing series from other OECD database (*e.g.* ISDB, STAN-1998, and STAN-1992) for a small subset of sectors[3] for which disaggregated data were not available in the other data-sets.

Table A5.3. **Average years of education of the working age population, 1971-1998**

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
United States	11.6	11.7	11.8	11.8	11.9	12	12	12.1	12.2	12.2	12.3	12.3	12.4	12.4
Japan	9.2	9.3	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.3	10.4	10.5
Germany	9.7	9.9	10.1	10.3	10.5	10.7	10.8	11.0	11.2	11.4	11.5	11.7	11.8	11.9
France	8.8	8.9	9.0	9.2	9.3	9.3	9.4	9.4	9.5	9.5	9.6	9.6	9.7	9.7
Italy	6.7	6.8	6.8	6.9	7.0	7.1	7.1	7.2	7.3	7.3	7.4	7.5	7.6	7.7
United Kingdom	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.4
Canada	11.4	11.5	11.5	11.6	11.6	11.7	11.8	11.9	12.0	12.1	12.1	12.2	12.2	12.2
Australia	11.1	11.1	11.2	11.2	11.3	11.4	11.4	11.5	11.5	11.6	11.6	11.7	11.8	11.8
Austria	9.8	9.8	9.9	10.0	10.0	10.1	10.2	10.3	10.3	10.4	10.5	10.6	10.7	10.8
Belgium	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.3	9.4	9.5	9.5
Denmark	9.9	10.0	10.1	10.2	10.2	10.3	10.4	10.5	10.5	10.6	10.7	10.7	10.8	10.8
Finland	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.7	9.8	9.9
Greece	7.5	7.5	7.6	7.6	7.7	7.7	7.8	7.8	7.9	7.9	8.0	8.1	8.2	8.2
Ireland	7.9	8.0	8.0	8.1	8.2	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.9
Netherlands	9.1	9.2	9.3	9.4	9.5	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.6
New Zealand	10.3	10.4	10.4	10.5	10.6	10.6	10.7	10.8	10.9	10.9	11.0	11.0	11.1	11.1
Norway	9.9	10.0	10.1	10.2	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1
Portugal	6.5	6.6	6.6	6.7	6.7	6.7	6.8	6.8	6.9	6.9	6.9	7.0	7.0	7.0
Spain	5.8	5.8	5.9	6.0	6.0	6.1	6.1	6.2	6.3	6.3	6.4	6.5	6.6	6.7
Sweden	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5
Switzerland	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.9	12.0

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
United States	12.5	12.5	12.5	12.5	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.7	12.7	12.7
Japan	10.5	10.6	10.7	10.8	10.8	10.9	11.0	11.1	11.1	11.2	11.3	11.4	11.4	11.5
Germany	12.1	12.2	12.4	12.6	12.7	12.9	13.1	13.1	13.2	13.3	13.4	13.4	13.5	13.5
France	9.8	9.8	9.8	9.9	9.9	10.0	10.0	10.2	10.3	10.4	10.5	10.6	10.6	10.6
Italy	7.8	7.9	8.0	8.1	8.2	8.4	8.5	8.6	8.8	9.0	9.2	9.4	9.6	9.8
United Kingdom	10.5	10.6	10.7	10.7	10.8	10.9	11.0	11.2	11.3	11.6	11.6	11.7	11.8	11.9
Canada	12.3	12.3	12.4	12.4	12.4	12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.9	12.9
Australia	11.9	11.9	12.0	12.0	12.1	12.1	12.2	12.2	12.2	12.3	12.3	12.3	12.3	12.3
Austria	10.9	10.9	11.0	11.1	11.2	11.3	11.3	11.4	11.4	11.4	11.5	11.6	11.7	11.8
Belgium	9.6	9.6	9.7	9.7	9.7	9.8	9.9	10.0	10.1	10.3	10.4	10.6	10.7	10.8
Denmark	10.9	10.9	10.9	11.0	11.0	11.0	11.1	11.1	11.2	11.2	11.3	11.3	11.4	11.4
Finland	10.0	10.1	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2
Greece	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.1	9.2	9.3	9.5	9.6	9.7	9.9
Ireland	9.0	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	10.0	10.1	10.2	10.3
Netherlands	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9
New Zealand	11.2	11.2	11.2	11.3	11.3	11.4	11.4	11.5	11.5	11.6	11.7	11.7	11.7	11.8
Norway	11.2	11.3	11.4	11.4	11.5	11.6	11.7	11.7	11.7	11.8	11.8	11.9	11.9	12.0
Portugal	7.1	7.1	7.1	7.2	7.2	7.2	7.3	7.3	7.4	7.5	7.5	7.6	7.7	7.7
Spain	6.8	6.9	7.0	7.1	7.2	7.3	7.5	7.6	7.8	7.9	8.1	8.3	8.5	8.7
Sweden	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.3	11.4	11.5	11.5	11.6	11.6
Switzerland	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.7	12.8	12.8	12.9	12.9	12.9	12.9

Source: De la Fuente and Doménech (2000) and OECD, *Education at a Glance*, various issues.

Table A5.4. **Industries used in the productivity analysis and classification according to the technology regime (manufacturing)**

STAN code	Industry name	Market structure*
5	Food products, beverages and tobacco	LT
6	Textiles	LT
7	Wood and products of wood and cork	LT
8	Pulp paper paper products printing and publishing	LT
11	Coke refined petroleum products and nuclear fuel	LT
13	Chemicals excluding pharmaceuticals	HTHC
14	Pharmaceuticals	HTHC
15	Rubber and plastic products	LT
16	Other non-metallic mineral products	LT
20	Basic metals	LT
21	Fabricated metal products except machinery and equipment	LT
23	Machinery and equipment n.e.c.	HTLC
24	Electrical and optical equipment	HTHC
25	Office accounting and computing machinery	HTHC
26	Electrical machinery and apparatus n.e.c.	HTHC
27	Radio television and communication equipment	HTHC
28	Medical precision and optical equipment	HTLC
30	Motor vehicles trailers and semi-trailers	HTHC
32	Building and repairing of ships and boats	LT
33	Aircraft and spacecraft	HTHC
34	Railroad equipment and transport equipment n.e.c.	HTHC
35	Manufacturing n.e.c. ; recycling	HTLC
41	Wholesale and retail trade; repairs	.
42	Hotels and restaurants	.
44	Transport and storage	.
45	Post and telecommunication	.
47	Financial intermediation	.
51	Real estate renting and business activities	.

* HTHC, HTLC and LT stand respectively for High-Tech High Concentration, High-Tech Low Concentration and Low-Tech industries.
Source: OECD.

As the analysis is conducted at the sectoral level, the choice between an output-based measure and a valued-added measure of productivity had to be made. However, material inputs were not available for a number of industries/ countries, and thus the second measure (based on value added) was adopted. Moreover, in a few cases when value-added deflators were missing, the deflators from the industry at the immediately higher level of aggregation were used.

The measure of labour input considered in the analysis is based on the total number of hours worked.[4] Time series data on *hours worked* at the sectoral level are from the ILO (LABORSTA) for the following countries:

Table A5.5. **Coverage of multi-factor productivity data**

Number of observations

Stan code[1]	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Italy	Japan	Netherlands	Norway	Portugal	Spain	Sweden	United Kingdom	United States
5	7	11	13	14	11	14	14	11	9	14	14	10	14	12	12	11	13	14
6	8	12	14	15	12	15	15	12	10	15	12	11	15	13	13	12	14	15
7	8	12	10	14	10	16	11	11	10	16	11	11	15	13	13	5	14	16
8	8	12	14	15	12	16	15	12	10	16	12	11	15	13	13	12	14	16
11	8	12	10	14	9	16	14	12	10	16	11	11	13	0	9	12	14	16
13	8	0	10	13	9	12	13	12	8	9	10	10	13	0	0	10	12	10
14	7	0	9	11	8	11	9	10	7	8	9	9	11	0	0	9	11	9
15	8	12	0	14	9	15	14	12	10	15	11	11	13	7	13	12	14	15
16	8	12	14	15	12	15	15	12	10	15	12	11	15	13	13	12	14	15
20	8	12	14	15	12	16	15	12	10	12	16	12	15	13	13	12	14	16
21	8	12	13	14	10	16	14	12	10	12	16	11	13	13	13	10	14	16
23	8	0	0	14	9	15	6	12	0	15	15	3	13	0	0	0	10	0
24	8	0	0	14	9	16	6	12	0	16	16	3	13	0	0	0	10	0
25	8	0	0	11	9	11	0	0	0	9	10	10	11	0	0	0	10	10
26	8	0	0	10	9	10	0	0	0	9	10	10	10	0	0	0	10	0
27	8	0	0	10	9	10	0	0	0	9	10	10	10	0	0	0	10	10
28	8	11	9	8	9	12	11	11	9	11	10	10	12	12	12	11	12	12
30	8	0	0	14	8	16	15	12	10	0	11	0	13	0	0	0	10	16
32	8	0	0	12	9	12	9	12	10	9	11	10	12	0	0	12	10	11
33	6	0	8	10	6	10	9	10	0	9	10	10	10	0	0	0	10	10
34	0	0	0	10	3	10	9	10	0	9	5	0	9	0	0	0	10	10
35	0	0	0	13	0	15	6	0	0	15	0	0	0	0	0	0	0	15
41	0	0	13	15	10	16	15	12	0	16	16	3	9	0	0	12	0	16
42	0	0	12	14	0	15	14	10	0	15	0	3	8	0	0	11	0	13
44	0	0	13	15	10	16	15	11	0	12	0	4	0	0	0	12	0	16
45	0	0	13	15	10	16	15	11	0	12	0	4	0	0	0	12	0	16
47	12	0	13	11	10	16	5	11	0	16	13	0	9	0	0	12	0	16
51	12	0	0	10	9	15	5	0	0	15	0	8	8	0	0	11	0	15

1. See Table A5.4. For details.

Source: OECD.

Australia, Austria, Finland, France, Norway, Portugal, Spain, Greece, Italy, Japan Netherlands and New Zealand. For the United States, data are from the BLS, while those for Canada are from the Canadian National Statistics Office. For the remaining countries (*e.g.* Belgium, Denmark and Germany), data are from CRONOS. In order to minimise cross-country differences in total hours worked, industry data were re-scaled on the basis of available nation-wide OECD data on hours worked. Moreover, for all manufacturing industries, hours data refer to the aggregate total, given the lack of intra-sectoral detail for most countries. Likewise, hours worked for the aggregate sector including *transport and storage* and *post and telecommunication* were used for the two sub-sectors. In addition, for the *trade* sector (ISIC3 50 to 52) and *hotels and restaurants* (ISIC3 55), data are only available for the combined industry for Norway, Japan and New Zealand. Finally, for Norway and New Zealand data for the combined sector *finance, insurance, real estate and business services* were used for all sub-sectors.

The OECD databases include information on the capital stock. However, in some instances, official series are incomplete. In such cases, gross fixed capital stock series were estimated using the perpetual inventory method (see Scarpetta and Tressel, 2002 for more details):

$$GCS_t = \sum_{j=0}^{2ASL-5} INV_{t-j} \cdot g_{t-j} \qquad \text{[A5.1]}$$

where: *GCS* is the gross capital stock at constant prices, *INV* is gross fixed capital formation at constant prices; *g* is the survival coefficient; *j* is the vintage of investment; *ASL* is the average service life. The survival coefficient is given by: g = 1 if j < 5 and g = 1 – ½(ASL – 5) if j > 4 and j–1 < 2ASL – 5 (depreciation starts at date t-5). The formula above implies the following recursive relation of the stock of capital for adjacent dates:

$$GCS_t = GCS_{t-1} + INV_t - \frac{1}{2(ASL-5)} \sum_{j=5}^{2ASL-5} INV_{t-j} \qquad \text{[A5.2]}$$

Gross capital stocks are calculated from this formula.

The calculation of MFP also requires estimates of the α *parameter*. As mentioned in Box 1.4 of Chapter 1, under perfect competition, α can be proxied by the share of labour compensation in total costs. The latter, however, is volatile, reflecting short-run fluctuations in demand conditions and possibly the fact that wages are not negotiated on an annual basis. In order to minimise these short-run fluctuations the share of labour compensation was regressed on country-industry fixed effects and on the logarithm of capital-labour ratio. Fixed effects account for unobserved factors influencing the technology used (such as endowments, available technologies, institutional factors). The country/sector-specific measures of the labour share is defined as the fitted value from this equation, which accounts for

country industry fixed components plus variations due to changes in the capital intensity.[5]

Finally, the calculations of sectoral MFP levels require the use of *comparative product price levels across countries* in order to convert the value of production to common units, while taking into account differences in the purchasing power of each country's currency. Purchasing power parities (PPPs) for GDP are fairly reliable and widely used in the empirical literature, but they may be problematic if relative prices of given industries evolve differently across countries.[6] Therefore, Chapter 3 uses a set of industry-specific PPPs as elaborated in a previous OECD work.[7] The starting point of these calculations were the PPPs for detailed expenditure headings from the United Nations International Comparisons Project (ICP). These detailed PPPs were mapped into the STAN classification of industries by assigning each basic expenditure heading bought by consumers, firms or the government to its industry of origin. When the basic heading includes products produced in more than one industry, the same price was assigned to all the industries concerned. Within each industry, proxies of the product prices were obtained aggregating the basic headings with the corresponding expenditure shares.

However, there are a number of problems in using expenditure PPPs for industry productivity comparison. In particular, the presence of distribution and transportation margins, indirect taxes and the inclusion/exclusion of the prices of imported/exported goods all tend to create a gap between expenditure prices and production prices. While available data did not allow accounting for distribution and transportation margins, corrections were made for both indirect taxes and international trade. In particular, in the above-mentioned Secretariat work, the correction for indirect taxes was made using the following formula

$$PPP_{i,j}^{adjI} = \frac{1+t_{i,j}}{1+t_{US,j}} \cdot PPP_{i,j} \qquad [A5.3]$$

where $t_{i,j}$ is the indirect tax rate of country i in industry *j*.

The impact of trade on the differential between expenditure and production prices is larger the more the sectoral expenditure price differs from the exchange rate. Since imports and exports have opposite effects on this differential, only the net trade position is relevant. The following adjustment was made to PPPs:

$$PPP_{i,j}^{adjII} = PPP_{i,j}^{adjI} + \frac{X_{i,j} - M_{i,j}}{Y_{i,j}} \cdot \left(e - PPP_{i,j}^{adjI}\right) \qquad [A5.4]$$

where X stands for industry exports, M for industry imports, Y for industry output, and *e* for the exchange rate.

Other Variables used in the industry-level analysis

Data on R&D *intensity* are drawn from the OECD ANBERD database. R&D intensity is defined as the ratio of Business Expenditure in Research and Development (BERD) to value-added. Value-added is from the main data-set discussed above.

Different measures of *human capital* were considered. First, macro-economic proxy for general human capital, such as the proportion of individual with secondary school attainment and the average number of years of schooling were considered (see Bassanini and Scarpetta, 2001). Contrary to Griffith *et al.* (2000), the coefficients on either of these two variables turned out to be statistically insignificant in MFP regressions. The second measure was an industry-level proxy of human capital, based on the skill composition of employment and relative wages by skill level. Thus, the measure of human capital was defined by (the subscripts *j*, *i* and t are omitted):

$$HumanCapital = \log\left[1+\frac{\omega_{HWh}}{\omega_{LWh}}.\frac{L_{HWh}}{L}+\frac{\omega_{HBl}}{\omega_{LBl}}.\frac{L_{HBl}}{L}\right] \qquad [A5.5]$$

where ω_{HWh}, ω_{LWh}, ω_{HBl}, ω_{LBl} are respectively the wage rate for the white-collar high-skill, white-collar low-skill, blue-collar high-skill and blue-collar low-skill workers. L_{HWh}, L_{HBl} and L are respectively white-collar high-skill employment, blue-collar high skill employment and total employment. Thus, this measure is rising with the wage premium of (white-collar and blue-collar) skilled workers relative to unskilled workers, weighted with the proportion of (white-collar and blue-collar) skilled workers in total employment.

In the next step, this variable is regressed on: 1) country-specific and industry-specific fixed effects; and 2) time dummies that are country and industry specific. The predicted value is used as a measure of human capital in the MFP regressions reported in the main text.[8]

All the economy-wide and sector-specific indicators of the stringency of *product market regulations* are from the OECD *International Regulation Database* (see Nicoletti *et al.*, 1999), except for the time-varying summary indicator of regulation that has been constructed from industry-level data (see Nicoletti *et al.*, 2001). In particular, the sectoral indicators cover energy and marketable service industries at the 3 or 4-digit level of ISIC Rev 3 classification (a total of 21 industries and industry aggregates) in (or around 1998) and, the time-varying indicator focuses on seven of them, over the 1975-1998 period. Depending on the industry, the resulting dataset covers barriers to entry, public ownership, price controls, government involvement in business operation, market concentration and vertical integration. In network industries – such as utilities, post and telecommunications and railways – the basic data concerned regulatory and market conditions in different (vertical or horizontal) segments of the industries (*e.g.* gas production, distribution and

supply, or regular and express mail). The main sources used to collect the data are the following:[9]

- the OECD: Regulatory Reform, Privatisation and Competition Policy (1992); The OECD International Regulation Database; OECD Roundtables on competition and regulation, various issues; OECD Reviews of Regulatory Reform, various issues; OECD Economic Studies, No. 32 (2001) (and background OECD Economics Department Working Papers Nos. 251, 237, 238, 254, 255); OECD Report on Regulatory Reform (1997).
- the European Conference of Ministers of Transportation: Rail Restructuring in Europe (1998); Regulatory Reforms in the Transport Sector (1987); Competition Policy and Deregulation of Road Transport (1990); Railway Reform (2001);
- the World Bank: Industry Structure and Regulation in Infrastructure: a Cross-Country Survey (1996);
- the European Commission: Liberalisation of Network Industries (1999) (and background documents); Green Paper on Postal Services (1993)
- Center for the Study of Regulated Industries/Privatisation International: I. Lewington (ed.), Utility Regulation (1997);
- Australian Productivity Commission: G. McGuire, M. Schuele and Smith, "Restrictiveness of international trade in maritime services", *Productivity Commission Staff Research Paper* (2000); K. Kalijaran, "Restrictions on trade in business services", *Productivity Commission Staff Research Paper* (2000); D. Nguyen-Hong, "Restrictions on trade in professional services", *Productivity Commission Staff Research Paper* (2000); *Trade and Assistance Review* 1998-99 (1999).

Further details about coverage and sources in each of the industries included in the analysis are provided in Table A5.6 and in Nicoletti et *al.*, 2001.

As for the nation-wide indicators of regulations, regulatory indicators by industry were based on basic cross-country data ordered according to the friendliness of regulations, market structures and industry structures to competition. The resulting cardinal indicators were re-scaled to ensure the comparability of the product market indicators across industries. The aim of this operation was to account for structural differences in industry characteristics, such as differences in minimum efficiency scale or vertical and horizontal relationships.[10] For each regulatory and market dimension covered in the dataset, cross-country indicators at the two-digit (ISIC Rev. 3) industry level were constructed by weighting the indices for lower-digit industries with average OECD employment shares. Finally, summary indicators of product market regulation by industry were derived taking the simple average of the regulatory dimensions covered in each industry.[11]

Table A5.6. **Industry-specific product market regulation: coverage and sources**

Industry	ISIC code Revision 3	Period	Regulatory and market dimensions covered[1]	Industrial segments covered	Countries covered	Main sources[2]
Electricity	401	1998	P, E, PD, MS, VI	Prod., trans., dist.	24-25	OECD
		1975-1998	E, PD, VI		21	OECD, EC, PI, WB
Gas manufacture and distribution	402	1998	P, E, PD, MS, VI	Prod., trans., dist.	26	OECD, EC, PI, WB
		1975-1998	E, PD, MS, VI		21	
Energy	40	1998	E, PD, VI	Prod., trans., dist.	25	OECD, EC, PI, WB
Water works and supply	41	1998	E, PD, VI		23	OECD, EC, PI, WB
Electricity, gas and water	40-41	1998	E, PD, VI		23	OECD, EC, PI, WB
Wholesale trade	50-51	1998	E, PD		25	OECD
Retail trade	52	1998	E, CBD		28	OECD
Restaurant and hotels	55	1998	E		25	OECD
Railways	601	1998	P, E, PD, MS, VI	Passenger, freight	27	OECD, ECMT
		1975-1998	E, PD, MS, VI		21	
Road freight	602	1998	P, E, CBD		27-29	OECD
		1975-1998	P, E		21	OECD, ECMT
Land transport	60	1998	P, E		27	OECD, ECMT
Water transport	61	1998	E, CBD		22	APC
Air transport carriers	62	1998	E, PD, MS	Passenger	27	OECD
		1975-1998	E, PD		21	OECD, EC
Transport	60-62	1998	E		22	OECD, ECMT EC, APC
Supporting services to transport	63	1998	E, PD		21	OECD
Post	641	1998	P, E, PD, VI	Letter, parcel, express	22-26	OECD, EC, UPU
		1975-1998			21	
Telecoms	642	1998	P, E, PD, MS, VI	Fixed, mobile	20-29	OECD
		1975-1998	E, PD, MS		21	
Communication	64	1998	P, E, PD, MS		26	OECD
Financial institutions	65	1998	E, CBD		23	OECD, APC
Insurance	66	1998	P, E	Life, general, health	12	OECD
Legal services	7 411	1998	E, CBD		22	APC
Accounting services	7 412	1998	E, CBD		23	APC
Architectural and engineering services	7 421	1998	E, CBD		23	APC
Professional business services	74	1998	E, CBD		22	APC

Note 1:
P = Price regulation
E = Barriers to entry
PO = Public ownership
CBO = Constraints to business operation
MS = Market structure
VI = Vertical integration
Note 2:
ECMT = European Conference of Ministers of Transportation
EC = European Commission
WB = World Bank
PI = Privatisation International
APC = Australian Productivity Commission
UPU = Universal Postal Union
Source: Nicoletti *et al.* (2001).

The time-varying indicator of product market regulations was obtained by using data on regulatory and market developments over the 1970-1998 period in seven energy and service industries: gas, electricity, post, telecommunications (mobile and fixed services), passenger air transport, railways (passenger and freight services) and road freight (see Nicoletti *et al.*, 2001). The coverage of regulatory areas varies across industries. Regulatory *barriers to entry* are reported for all industries; *public ownership* is reported in all industries except road freight; *vertical integration* is documented for gas, electricity and railways; *market structure* is documented for gas, telecommunications and railways; and *price controls* are reported for road freight. The aggregate time-series indicator of regulation was constructed by taking a simple average of the summary indicators for the seven industries. The resulting indicators were interpreted as a proxy for the overall regulatory policies followed by OECD countries over the sample period.

A5.4. Chapter 4 : Firm-level data

The data and methods used in the productivity decompositions and analysis of firm dynamics presented in Chapter 4 were built within the context of the OECD firm-level project, involving ten countries (Canada, Denmark, France, Finland, Germany, Italy, the Netherlands, Portugal, the United Kingdom, and the United States). These data and methods are described in Annex 4 above. Further details are contained in Tables A5.7 and A5.8.[12]

Notes

1. The estimates of gross capital stock were based on BEA's former gross stock measure up to 1993, the last available update. More recent estimates were obtained as follows: the historical series of gross stock were regressed against BEA's net stock series and BLS' capital services series. For years after 1993, the gross stock was then estimated as the predicted value from this regression, using recent observations on the net stock and on capital services.
2. De la Fuente and Doménech (2000) revised the original series from Barro and Lee (1996) to eliminate anomalies in connection with attainment rates.
3. Chemicals excluding Pharmaceuticals, Pharmaceutical, Building and Repairing of Ships and Boats, Aircraft and Spacecraft, Railroad Equipment and Transport Equipment N.E.C.
4. For a sensitivity analysis of the empirical results of Chapter 4 using alternative estimates of labour input, see Scarpetta and Tressel (2002).
5. For a sensitivity analysis of the empirical results of Chapter 3 using alternative estimates of the labour share, see Scarpetta and Tressel (2002).
6. For example, Sørensen (2001) shows that aggregate PPPs may be somewhat problematic to study country convergence in manufacturing productivity. Indeed, while relative productivity levels are independent of the choice of the base year,

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using PPPs for total GDP leads to different degree of convergence depending on the base year chosen for PPPs. This may be due to the fact that relative prices of manufacturing have evolved differently across countries, but may also reflect the fact that PPPs for total GDP have improved over time. See also Schreyer and Pilat (2001) for a discussion on these issues.

7. These data are available upon request. For a sensitivity analysis of the empirical results of Chapter 3 using alternative (*i.e.* aggregate) measures of PPPs, see Scarpetta and Tressel (2002).
8. The coefficient remains significant with the same sign if the original variable is used instead of the predicted one in the productivity regressions. The use of the original variable, however, reduces somewhat the sample size, and thus it was decided to use the predicted human capital variable.
9. Other sources include the International Energy Agency, the Universal Postal Union and the National Economic Research Associates.
10. For instance, indicators for barriers to entry in each industry were rescaled using the OECD average of the frequency of barriers to entry in that industry. As a result, indicators of barriers to entry in structurally competitive industries (such as retail distribution) take by construction a lower range of values than indicators of barriers to entry in industries having natural monopoly elements (such as electricity).
11. Unlike the economy-wide indicators of product market regulation, the dimensions available for time-series data were too few to be able to aggregate detailed indicators by means of factor analysis.
12. For an overview of the issues encountered in the use of firm-level data and details on the subsequent research protocol, see Scarpetta *et al.* (2002).

Table A5.7. **Description of data used in analysis of firm demographics**

	Canada	Denmark	Finland	France	western Germany
Type of data ("Register", "Sample", or "Other")	Register	Register	Register	Register	Register
Name of data source(s)	Statistics Canada Business Register	Pay and performance database	Business register	Fiscal database ("BRN" file) with additional information from the Enterprise survey ("EAE" file)	Social security data
Comment on register or sampling method			There are some changes in the business register. *i)* coverage was improved in 1994 for small and very small enterprises, *ii)* some technical changes in 1995 and 1996, but the effects are not very large	For technical reasons not all observations could be used in constructing the longitudinal data in the manufacturing sector with the result that employment figures in manufacturing implied in the data fall short of those from other sources	
Unit of observation	Firm	Firm and plant	Firm and plant	Firm	Plant
Comment on unit of observation					
Periodicity and timing	Annual	Annual (end of November)	Annual: units, which have survived 6 months, at minimum, are included in the statistical business register	Annual (end of year)	Annual
First year	1984	1980 (firm and plant data)	1988	1989	1978
Last year	1998	1994 (firm data) 1993 (plant data)	1998	1997	1998
Breaks			1994-1995, change in coverage (see above), and in 1995 and 1996		No

Table A5.7. **Description of data used in analysis of firm demographics** *(cont.)*

	Canada	Denmark	Finland	France	western Germany
Size threshold	At least one employee	At least one employee	At least one employee	"BRN" file covers firms with more than 3.8 million FFr turnover per year in manufacturing and 1.1 million FFr turnover in the service sector are covered. EAE file	At least one employee. *Note:* the civil service, the self-employed and certain other groups are excluded from making social security payments and are not included in the data
Does employment data reflect employees only or "total" employment?	Employees		Employees		Employees
Sectoral coverage	All sectors	All sectors	All sectors	All sectors	All sectors (except civil service, see size threshold)

Table A5.7. **Description of data used in analysis of firm demographics** *(cont.)*

	Italy	Netherlands	Portugal	United Kingdom	United States
Type of data ("Register", or "Sample", or "Other")	Register	Register	Register	Register	Register
Name of data source(s)	Social security data	General Business Register	*Quadros do pessoal* (administrative establishment-based database)	CSO Business Register [also known as the ACOP Respondents Database (ARD)]	Longitudinal Business Database Prototype (Source data is the SSEL with CES value added)
Comment on register or sampling method	All firms in the private sector with at least one employee	All firms are included	Public employees and private services to households not included		All taxpaying employer businesses (EINs)
Unit of observation	Firm	Firm	Firm and plant	Firm. *Note:* the units conform to Eurostat enterprise definitions and represent the lowest autonomous units within a company	Establishment and firm
Comment on unit of observation	Observations are legal entities registered with the social security agency.			Change in definition of reporting unit in 1987. Impact not considered to be large. In 1994: New register, moved to Eurostat enterprise definitions. Almost total break in data series	Firm level data supplied
Periodicity and timing	Monthly	Monthly	Annual: March (1983-1993), October (1994-1998)	Annual (timing varies)	Annual
First year	1986	1987	1983	1980. *Note:* data in fact date back to 1973, but incomplete employment data until 1980)	1989
Last year	1994	1997	1994	1992. *Note:* 1994-1997 are based on a new register and cannot easily be linked	1996

Table A5.7. **Description of data used in analysis of firm demographics** *(cont.)*

	Italy	Netherlands	Portugal	United Kingdom	United States
Breaks		1993: change in industry classification	1995: change in SIC code	1984: significant change in register (due to inclusion of VAT register). "One-year" category large due to incorrect classification between the registers 1987: change in definition of reporting unit, impact not great. 1994: new register, comprehensive linking not yet achieved	No
Size threshold	At least one employee	At least one employee	At least one employee	At least one employee. *Note*: smaller observations may be older due to restrictions to protect small firms	At least one employee
Does employment data reflect employees only or "total" employment?	Employees	Employees	Employees	Employees	Employees
Sectoral coverage	All sectors (see main text)	All sectors	All but public administration	Manufacturing only	Private businesses
Other relevant comments	See main text	Employment data only available from 1993 onwards		Data show some considerable variation between some years of data. Most likely explanations lie in the various breaks described above. Protection from reporting requirements for small firms may mean they are under-represented compared to other databases	

Table A5.7. **Description of data used in analysis of firm demographics** *(cont.)*

Supplementary notes:

France:

The register for the manufacturing sector has expanded to cover an increasing number of businesses over time. In order to prevent this expansion being reflected as firm entries, only a subset of the register data are used. As a result the employment figures for manufacturing in the data fall short of those from other sources; although they are still be representative with regard to the productivity decompositions and the analysis of firm demography.

Italy:

Two issues are worth noting about the nature of entries and the extent to which entries and exits reflect mergers and acquisitions. For entry, the date registered is when the first hiring occurs. Thus, for example, the "entries" may reflect cases where (usually small) enterprises decide to employ individuals on an official basis. Mergers and acquisitions cannot be identified across the data as whole, but there has been some estimation of their importance in certain regions and sectors. According to some studies using INPS data for particular regions and periods: between 10 and 15 per cent of entry is a change of legal status, 20 per cent involves a substantial change of pre-existing firms, and 65-70 per cent is "pure" entry (equivalent figures are likely to hold for exiting firms). In addition, there are some minor problems in conforming to the OECD STAN sector classification. The INPS data are based on the Italian classification Ateco81: although most matches are accurate, some are more problematic. The Ateco81 sector "Metals and machinery nec", is attributed to the STAN "Machinery and Equipment nec". The Ateco81 sector "Measurement and Telecomm. Equipment", is placed in the STAN sector "Communication Equipment". Ateco81 330, which includes both the production and repair and maintenance of computing machines, is attributed to the STAN "Office, accounting and computing equipment", even though in theory part of it should be attributed to business services.

The United Kingdom:

The analysis of firm demographics for the United Kingdom uses data for the end of the time span covered (1989 to 1993). It should be noted that early years of the data show some large changes in the number of firms over time.[1] These are attributable to a variety of factors including register and changes in reporting unit. For the more recent years of available data the sectoral distribution of the firm-level data is considered representative. In aggregate terms the employment data from the UK micro data is slightly below the reported employment for UK manufacturing, and this is consistent over time.

1. For example, the total number of continuing firms falls from around 75 000 to 20 000 between 1982 and 1993 and increases to about 85 000 in 1986.

Source: OECD.

Table A5.8. **Description of data used in productivity decompositions**

	Finland	France	western Germany	Italy
Type of data ("Register", "Sample", or "Other")	Census	Register	Sample	Sample
Name of data source(s)	Industrial statistics	Fiscal database ("BRN" file) with additional information from the Enterprise survey ("EAE" file)	IAB Establishment Panel	Company Accounts Database
Comment on register or sampling method		For technical reasons not all observations could be used in constructing the longitudinal data in the manufacturing sector with the result that employment figures in manufacturing implied in the data fall short of those from other sources	Sample based on random draws from cells based on 16 sectors and 10 plant sizes. Total sample (all Germany) approx. 8 000. Sample data are weighted to generate population-equivalent data	Approximately 40 000 firms per year. Sampling method: firms with at least 5 million euro of turnover, or with multiple bank relationships. The total sample is kept roughly the same size, adding or deleting firms that are in the proximity of the selection threshold
Unit of observation	Plant and enterprise code (thus industrial plants included)	Firm	Plant	Firm
Comment on unit of observation				Legal entity with a unified balance sheet
Periodicity and timing	Annual (end of year)	Annual (end of year)	Annual	Annual, end of year
First 5-year period	1975-1980 1988-1993 (services)	1985-1990	1992-1997	1983-1988
Last 5-year period	1993-1998 1993-1998 (services)	1990-1995	1993-1998 (sales data limit number of years that can be covered)	1993-1998
Breaks	1994-1995, change in size threshold		No	In 1993-1994 there has been a change in the data collection procedures. As a result, entry is abnormally high in those 2 years, and similar for exit, 1994-1995

Table A5.8. **Description of data used in productivity decompositions** *(cont.)*

	Finland	France	western Germany	Italy
Size threshold	All plants with at least 5 persons. Since 1995, all plants owned by firms having at least 20 employees	"BRN" file covers firms with more than 3.8 million FFr turnover per year in manufacturing and 1.1 million FFr turnover in the service sector are covered. EAE file is a sample of firms with more than 20 employees	Plants with at least one employee	Firms with more than 5 million euro turnover per year
Sectoral coverage	Manufacturing (except 2 observations for services)	Manufacturing	Manufacturing and total services	All sectors
Issues relating to output data		Value added	Gross output used in calculations	
Issues relating to labour input data			Employees	Employment is added on to the balance sheet data. Despite some concerns, random checks on the employment figures suggest they are reliable. Only the number of employees is available
Issues relating to capital stock			No capital stock data available	Capital stock is reconstructed from balance sheet information using a permanent inventory method. Initial capital stock is estimated using a measure of average age of capital with appropriate deflation
Issues relating to price data	Value-added price data only available at the 2-digit level (about 15 industries). Producer price and unit value indices available at the 3 or 4-digit level	All price data at the "naf 36" level	There are breaks in price data between 1993 and 1999	All price data at 2-digit level

Table A5.8. **Description of data used in productivity decompositions** *(cont.)*

	Netherlands	Portugal	United Kingdom	United States
Type of data ("Register", "Sample", or "Other")	Register and sample	Register	Sample	Quinquennial Census of Production
Name of data source(s)	Production Statistics Survey	*Quadros do pessoal* (administrative establishment-based database)	Annual Census of Production. (ACOP) Respondents Database (ARD)	Census of Manufacturing
Comment on register or sampling method	The Production Statistics Survey includes all firms with at least 20 employed persons, and a random sample for smaller firms. Sample data (for smaller firms) are weighted to generate population-equivalent data	The self-employed, public employees and private services to households not included	Sample data are weighted to generate population-equivalent data. Weights derived from employment on CSO Business Register (ARD non-selected files)	Universe
Unit of observation	Firm	Firm (plant data also available but not used in this study)	Lowest autonomous unit within firm	Establishment and firm
Comment on unit of observation			Change in definition of reporting unit in 1987. Impact not considered to be large. In 1994. New register, moved to Eurostat enterprise definitions. Break in data series	Firm level tabulations supplied
Periodicity and timing	Annual	Annual. March (1983-1993) October (1994-1998)	Annual (timing varies)	5-year
First 5-year period	Manufacturing: 1980-1985 Business services: 1987-1992		1980-1985	1987-1992
Last 5-year period	Manufacturing: 1992-1997 Business services: 1991-1996		1993-1998	1992-1997 (no intervening years)

Table A5.8. **Description of data used in productivity decompositions** *(cont.)*

	Netherlands	Portugal	United Kingdom	United States
Breaks	1993: change in industry classification	1995: change in SIC code	1984: significant change in register (due to inclusion of VAT register). "One-year" category large due to incorrect classification between the registers. 1987: change in definition of reporting unit, impact not great. 1994: new register, comprehensive linking not yet achieved	No
Size threshold	Firms with at least 20 employees in manufacturing, firms with at least 5 employees in business services	At least one employee	At least one employee (smaller observations may be older due to restrictions to protect small firms)	At least one employee
Sectoral coverage	Manufacturing, business services (computer and related activities, other business activities)	All but public administration	Manufacturing only	Manufacturing
Issues relating to output data	Gross output: value of total turnover plus change in stocks + margin on trading and other revenues		Gross output	Gross output adjusted for inventories and deflated using Gray/ Bartelsman/Becker 4-digit SIC deflators
Issues relating to labour input data	Employees	Employees	Employees	Number employees on March 12
Issues relating to capital stock	No capital stock available		Generated from investment questions on ARD using perpetual inventory method. Initial stocks based on industry data apportioned using energy usage data from ARD	
Issues relating to price data	Producer price indices for total turnover. If available at the 3-digit level of ISIC; otherwise at the 2-digit level	2-digit level (from national accounts)	4-digit for output and materials, 2/3-digit for capital	

Source: OECD.

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